The state of phytoplankton and bacterioplankton at the Compass Buoy Station: Bedford Basin Monitoring Program 1992-2013

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ABSTRACT

Li, W.K.W. 2014. The state of phytoplankton and bacterioplankton at the Compass Buoy Station: Bedford Basin Monitoring Program 1992-2013. Can. Tech. Rep. Hydrogr. Ocean. Sci. 304: xiv + 122 p.

Since 1992, the Bedford Basin Monitoring Program has undertaken dedicated oceanographic sampling at the Compass Buoy Station on a nominal weekly basis. This report presents a detailed record of microbial plankton in the context of their immediate physical and chemical environment at this station from 1992 to 2013. It provides information on microbes that is supplementary to annual data of the core program reported to the Canadian Science Advisory Secretariat. Descriptions are given for both the climatological mean state and the interannual change for picophytoplankton, nanophytoplankton, bacterioplankton, associated phytoplankton pigments, and light absorption by phytoplankton. The physical (temperature, salinity, stratification, light attenuation), chemical (nitrate, phosphate, silicate, ammonium, oxygen, particulate organic carbon and nitrogen), and biological variables are compared on the common basis of dimensionless standard anomalies. The results of such comparisons are ordered sequences of variables ranked by relative temporal coherence within the 53-week annual cycle, and also over the multiyear time span from 1993 to 2013. The Bedford Basin system appears to have characteristics indicating both local and regional trends. On the one hand, the recent state of low bacteria and low phosphate seems to be a local trend. On the other hand, the continuing increase of picophytoplankton seems to be a trend that is shared with systems at other locations on the Scotian Shelf.

RÉSUMÉ

Li, W.K.W. 2014. Situation du phytoplancton et du bactérioplancton à la station de bouée de réglage de compas : Programme de surveillance du bassin de Bedford 1992-2013. Rapp. tech. can. hydrogr. sci. océan. 304: xiv + 122 p.

Depuis 1992, le programme de surveillance du bassin de Bedford a entrepris un échantillonnage océanographique dédié à la station de bouée de réglage du compas sur une base hebdomadaire régulière. Ce rapport présente un dossier détaillé sur le plancton microbien dans le contexte de son environnement physique et chimique immédiat à cette station de 1992 à 2013. Il fournit des renseignements sur les microbes qui viennent compléter les données annuelles du programme de base déclarées au Secrétariat canadien de consultation scientifique. Les descriptions sont fournies pour l'état moyen du climat et la variation interannuelle du picophytoplancton, du nanophytoplancton, du bactérioplancton, des pigments phytoplanctoniques associés ainsi que de l'absorption de la lumière par le phytoplancton. Les variables physiques (température, salinité, stratification, atténuation de la lumière), chimiques (nitrate, phosphate, silicate, ammonium, oxygène, carbone organique en particules, azote) et biologiques sont comparées sur une base commune d'anomalies adimensionnelles standard. Les résultats de ces comparaisons sont des séquences ordonnées de variables classées par cohérence temporelle dans le cycle annuel de 53 semaines et également sur la durée de la période de plusieurs années entre 1993 et 2013. Le système du bassin de Bedford semble avoir des caractéristiques indiquant les tendances locales et régionales. D'un côté, la situation récente des faibles taux de bactéries et de phosphate semble être une tendance à l'échelle locale. D'un autre côté, la tendance à l'accroissement continu du picophytoplancton semble être partagée avec des systèmes à d'autres emplacements sur le plateau néo-écossais.

PREFACE

This is one in a set of three reports that document the mean state and interannual change of phytoplankton and bacterioplankton in the ocean waters of Atlantic Canada from program inception to the end of 2013. This report documents the observations made at the Compass Buoy Station in the Bedford Basin Monitoring Program. The companion reports document observations made on the Scotian Shelf and Slope in the Atlantic Zone Monitoring Program[1], and in the Labrador Sea in the Atlantic Zone Off-Shelf Monitoring Program[2]. Together, this set of three reports comprises an integrated technical output of the core non-research component of microbial oceanographic activity in Ocean and Ecosystem Sciences Division aligned to the DFO hierarchical program architecture of Sustainable Aquatic Ecosystems / Oceans Management / Ecosystem Assessments / Aquatic Ecosystems Science.

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[1] Li, W.K.W. 2014. The state of phytoplankton and bacterioplankton on the Scotian Shelf and Slope: Atlantic Zone Monitoring Program 1997-2013. Can. Tech. Rep. Hydrogr. Ocean. Sci. 303: xx + 140 p.

[2] Li, W.K.W. and W.G. Harrison 2014. The state of phytoplankton and bacterioplankton in the Labrador Sea: Atlantic Zone Off Shelf Monitoring Program 1994-2013. Can. Tech. Rep. Hydrogr. Ocean. Sci. 302: xviii + 181 p.

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1. INTRODUCTION

1.1 AIMS AND STRATEGY

Bedford Basin Monitoring Program (BBMP) is a perpetual and uninterrupted observational record of the plankton ecosystem aimed at discerning normal conditions, natural variability, and long-term trends at the Compass Buoy Station. On a weekly basis, measurements are made of selected properties that characterize the physical, chemical, biological and optical environments of the water column[3]. The core program also provides the logistical and information backbone supporting additional value added research.

In aspiring towards a goal of monitoring climate and plankton variability, BBMP has ostensibly adopted an analytic strategy to link cause and effect - a focus on mechanistic oceanographic processes over indeterminate complex environmental history, which, arguably, may be a useful alternative to a synthetic approach for managing ecological futures. With this strategy, BBMP is firmly grounded in phenomenological description of the cumulative oceanographic data collection. The ensuing data reduction and statistical predictions are not explicitly referenced to a null hypothesis in the tradition of hypothetico-deductive science amenable to strong test. Instead, BBMP collects circumstantial evidence that corroborates (or not) the alternative hypothesis of biological change produced by a physical or chemical cause of interest. In this reductionist heuristic, we accept that the reification[4] of statistics constructs the knowledge representation which enables us to understand and explain, at least in a probabilistic manner.

1.2 BACKGROUND

From an oceanographic standpoint, Bedford Basin is one of the most well-studied sites in Nova Scotia. The location of the Bedford Institute of Oceanography on the shore of the Basin has facilitated numerous diverse studies in the past five decades. Some of these studies were undertaken because they were investigations of general scientific principles which simply required an easily accessible water body. Other studies were aimed at understanding the specific nature of the Basin itself. In a coastal ecosystem such as Bedford Basin, biological populations undergo large natural fluctuations, upon

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[3] http://www.bio.gc.ca/science/monitoring-monitorage/bbmp-pobb/bbmp-pobb-eng.php

[4] Slobodkin (2001) explains that "[r]eification consists of accepting a designation as if it has empirical meaning when, in fact, its existence has either never been tested or it has been found empty…reification is taken as an untestable axiom…To reify consists of assigning to a word, quantity or image an illegitimate ontological status".

which may be superimposed the effects of human activities. The ability to discern the latter from the former depends on a time series of relevant measurements made at an appropriate frequency for an extended period.

BBMP was conceived and carried out by a small team, beginning in 1991 (Li et al. 1998), with the aim of discerning long-term ecological change in the water column[5]. Later, in 1997, the Atlantic Zone Monitoring Program (AZMP) was assembled as the flagship ocean observing program undertaken by DFO in the Northwest Atlantic Ocean (Therriault et al. 1998). Importantly, Bedford Basin was designated as the only near-shore complement to six offshore fixed stations that are sampled at high-frequency in the Atlantic Zone Monitoring Program (AZMP).

1.3 PURPOSE

The present report has a two-fold purpose. First, it describes the annual 53-week cycle for the climatological mean state of picophytoplankton, nanophytoplankton, bacterioplankton, phytoplankton pigments, phytoplankton light absorption, and associated physical and chemical variables. For this descriptive purpose, we tabulate the average value of each variable for every week in the year. This description allows a synthetic consideration of inter-weekly patterns of coherence and anti-coherence amongst all variables in their normal (climatological) state.

Second, this report relates the multiyear change of microbial plankton variables to their physical and chemical environment. For this descriptive purpose, we coarse-grain the weekly averages into monthly norms and anomalies, and then we combine the monthly anomalies as a reification of annual-based departures from the normal state. This description allows a synthetic consideration of inter-annual patterns of coherence and anti-coherence amongst all variables as they change from year-to-year. This report is a detailed evidentiary record of microbial plankton and their environment in the Bedford Basin, against which scientific hypotheses may be tested.

2. METHODS

2.1 SAMPLING AND ANALYSES

The Compass Buoy Station (44° 41' 37" N, 63° 38' 25" W) is situated in the deepest part (~70m) of Bedford Basin (Figure 1). The nominal schedule for sampling is once per

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[5] The sedimentation of suspended particulate matter is not an element of BBMP, but has been studied by others (Hargrave and Taguchi 1978).

week, usually on a Wednesday morning, but this is adjusted when necessary to accommodate operational and program contingencies. To the end of 2013, BBMP had completed about 1100 station occupations. On station, a profiling conductivity-temperature-depth (CTD) system records pressure, conductivity, temperature, photosynthetically active radiation (PAR), in vivo fluorescence, and dissolved oxygen. Data are processed to 0.5 m depth resolution.

Water samples are collected by Niskin bottle at 1, 5, 10, and 60m depths. Standard AZMP method protocols are used for the analyses of nutrients by segmented flow analysis and of bulk chlorophyll by fluorometry (Mitchell et al. 2002). Dissolved oxygen at 5m and 60m is measured by optode (Hach IntelliCAL LDO101) connected to a portable meter (Hach HQ30d). Particulate organic carbon (POC) and nitrogen (PON) at 5m and 60m are measured by Perkin Elmer Series II CHNS/O Analyzer 2400. The spectrophotometric method for the measurement of light absorption by particles sampled at 1m, and the calculations for light absorption by phytoplankton are made according to Hoepffner and Sathyendranath (1992, 1993). For picophytoplankton (picoeukaryotic algae and *Synechococcus* cyanobacteria), nanophytoplankton, and bacterioplankton, samples are fixed with paraformaldehyde, stored at -80°C, and analysed by flow cytometry (Li and Dickie 2001).

For phytoplankton pigments, the method of high performance liquid chromatography (Stuart and Head 2005) was used to estimate concentrations of the following pigments at 1, 5, 10, and 60m:

- 19'-butanoyloxyfucoxanthin [But-fuco]
- 19'-hexanoyloxyfucoxanthin [Hex-fuco]
- alloxanthin [Allo]
- chlorophyll *a* [Chl*a*]
- chlorophyll *b* [Chl*b*]
- chlorophyll *c* [Chl*c*]
- diadinoxanthin [Diadino]
- fucoxanthin [Fuco]
- peridinin [Peri]
- zeaxanthin [Zea]

Following Uitz et al. (2006), we apportioned diagnostic pigments to cell size classes as follows:

Microphytoplankton pigments (mg m^{-3})
MICROPIG = 1.41[Fuco] + 1.41[Peri]

Nanophytoplankton pigments (mg m^{-3})
NANOPIG = 1.27[Hex-fuco] + 0.35[But-fuco] + 0.60[Allo]

Picophytoplankton pigments (mg m^{-3})
PICOPIG = 1.01[TChl*b*] + 0.86[Zea]

Thus the weighted sum of diagnostic pigments (mg m^{-3}) is given by:
DIAGPIG = MICROPIG + NANOPIG + PICOPIG

And the fractional contribution of each size class to the sum is given by:
F-MICRO = MICROPIG/DIAGPIG
F-NANO = NANOPIG/DIAGPIG
F-PICO = PICOPIG/DIAGPIG

It should be noted that since we did not undertake a local calibration of this general method to obtain custom weighting coefficients for Bedford Basin phytoplankton, there is uncertainty in the quantitative assignment of the 7 pigments to the 3 size classes.

2.2 DATA HANDLING

At the time of collection, each water sample is assigned a unique 6-digit identification number that serves to link all variously-measured physical, chemical, and biological variables to the date, time, and depth of sampling. Hydrographic data (temperature, salinity, pressure, density) are extracted from continuous vertical profiles to match the actual depths from which water samples are collected. Vertical stratification of the water column (kg m^{-4}) is calculated as the depth-normalised difference of seawater density between deep (60m) and shallow (average of 1, 5, and 10m) waters. All data are compiled and consolidated into a single flat file. Data manipulations are handled using an Excel pivot table created from the flat file.

2.3 DATA PRESENTATION

2.3.1 Weekly climatologies

The 53-week climatology of every variable sampled at each depth is computed by averaging values that are measured in the same week number of the year (specified by the Excel date function `WEEKNUM`) for all years in the time series. These weekly norms are presented in tabular form.

2.3.2 Monthly climatologies

The 12-month climatology of every variable in surface water (average of 1, 5, and 10m samples) and in deep water (60m) is computed as follows. First, a simple line plot of the entire time series of weekly measurements (top panel of graph page) is visually inspected for data integrity and quality assurance.

Second, for each year in the time series, the weekly measurements are binned by month and then averaged. For each variable, this procedure yields 22 x 12=264 month-binned average values, or less if the time series does not extend for 22 years (middle left panel of graph page, green dots). The grand average for each month taken over all years is the monthly norm (middle left panel of graph page, red circle).

Third, a visual display is made of the month-binned averages in a 22 x 12 matrix of year x month (middle right panel of graph page). The values for all the month-binned averages are sorted numerically and then divided into 20 equal-n member rank groups. The rankings are then assigned a colour from the rainbow palette, with low monthly mean values assigned to short wavelength colours, and high values to long wavelength colours[6].

2.3.3 Monthly anomalies

Monthly anomalies are the departures (arithmetic differences) of the month-binned averages (green dots) from the monthly norm (red circles). A monthly anomaly divided by its month-specific standard deviation gives the normalised monthly anomaly. This z-standardised quantity measures the deseasonalised departure of the variable from normal conditions in standard deviate unit.

A visual display is made of the normalised monthly anomalies in a 22 x 12 matrix of year x month (bottom left panel of graph page). Positive anomalies are coloured red and negative anomalies are coloured blue, with stronger hues assigned to stronger anomalies. Strong positive anomalies are defined as those greater than the mean of all positive anomaly values in the time series. Likewise, strong negative anomalies are those less than the mean of all negative anomaly values.

2.3.4 Annual anomalies

Annual anomalies are the net average (positive or negative) of all 12 normalised monthly anomalies in each year. The multiyear trend of annual anomalies is indicated by a 3-year running average (bottom right panel of graph page).

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[6] A possible alternative classification is division of month-binned averages into equal-interval member rank groups, in which case some classes are likely to have only a very small number of members. The choice between these alternative classifications is largely one of cognitive preference.

2.4 DATA SUMMARY

2.4.1 Annual cycles

2.4.1.1 Cluster heat map

To discern inter-weekly coherence of 40 surface layer variables, we use a colour-coded 2-dimensional visual display to summarise the annual cycles of variables, a version of the cluster heat map (Wilkinson and Friendly 2009). We first adjusted the weekly norm for each variable by z-standardisation to zero mean and unit deviation: $X' = \frac{(x-\overline{x})}{s_x}$, where X' = adjusted norm, X = weekly norm, $\overline{X}$ = average weekly norm, s_X = standard deviation of weekly norms. Positive values of the adjusted weekly norms are coloured red whereas negative values are coloured blue, with stronger hues assigned to stronger departure from zero mean. Strong positive values are defined as those greater than the mean of all positive values in the 53-week cycle. Likewise, strong negative values are those less than the mean of all negative values.

We then performed principal component analysis on the adjusted weekly norms of the variables, and ranked the 40 variables by the loading of the first principal component. A variable x week number matrix displays the variables in a vertical sequence ranked from the highest positive loading to the highest negative loading, arrayed along a horizontal sequence of week number. Variables close to each other in component ranking reflect a degree of similarity in their temporal dynamics from week to week. Vice versa, variables far apart from each other in rank with opposite signs reflect a degree of inverse similarity. This allows the visualisation of any coherence (or anti-coherence) in the manner in which suites of these variables are changing over the weeks within a year.

2.4.1.2 State space plots

A system can be specified by the n-dimensional space of possible locations of state variables (see Section 4.2). For a 13-element subset of the measured variables in this study, we display a full matrix of bivariate plots, each showing the 12-point trajectory of the unadjusted monthly norms (from Section 2.3.2) for different combinations of 2 variables at a time. This graphic display shows the relationship between paired variables in the normal (climatological) annual cycle of the system.

2.4.2 Multiyear trends

2.4.2.1 Cluster heat map

To discern inter-annual coherence of multiyear change in variables (for which the time series length is $\geq$18 years), we use a similar cluster heat map to summarise the

year-based time series from 1993-2013, as indicated by the normalised annual anomalies (Section 2.3.4).

We performed principal component analysis on the normalised annual anomalies of the variables, and ranked the 28 variables by the loading of the first principal component. A variable x year matrix displays the variables in a vertical sequence ranked from the highest positive loading to the highest negative loading, arrayed along a horizontal sequence of years. We follow Frank (2003) in using this method to discern the ordinated pattern of how normalised anomalies of ecosystem variables are changing over time from year-to-year. Variables close to each other in component ranking reflect a degree of similarity in their temporal dynamics from year-to-year. Vice versa, variables far apart from each other in rank with opposite signs reflect a degree of inverse similarity. This allows the visualisation of any coherence (or anti-coherence) in the manner in which suites of these variables are changing over the years.

2.4.2.2 State space plots

A system can be specified by the *n*-dimensional space of possible locations of state variables (see Section 4.2). For a 13-element subset of the measured variables in this study, we display a partial[7] matrix of bivariate plots, each showing the 21-point (or less) trajectory of the annual average values for different combinations of 2 variables at a time. This graphic display shows the relationship between paired variables forming a long-term temporal trend as the system transitions through the time series from 1993 to 2013.

2.5 DATA AVAILABILITY

The data in this report are available from the BioChem database maintained by DFO Integrated Science Data Management[8]. The data have also been submitted to the International Council for the Exploration of the Sea (ICES) Working Group on Phytoplankton and Microbial Ecology (WGMPE)[9], as well as the UNESCO Intergovernmental Oceanographic Commission (IOC) International Group for Marine Ecological Time Series (IGMETS)[10].

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[7] Not all bivariate pairs are plotted for the purpose of reducing visual clutter.

[8] http://www.meds-sdmm.dfo-mpo.gc.ca/biochem/biochem-eng.htm

[9] http://wgpme.net

[10] http://igmets.net

3. RESULTS

3.1 TEMPERATURE

[Table 1; Figures 2, 45]
Weekly norms of temperature at 1m and 5m are almost perfectly correlated ($r = 0.96$), and remain strongly correlated for those at 1m and 10m ($r = 0.88$). Monthly norms of surface (deep) temperature are lowest in February (April) and highest in September (January). The recent running average trend of annual anomalies of surface (deep) temperature is positive (positive).

3.2 SALINITY

[Table 2; Figures 3, 46]
Weekly norms of salinity at 1m and 5m are correlated ($r = 0.52$), but those at 1m and 10m are poorly correlated ($r = 0.26$). Monthly norms of surface (deep) salinity are lowest in May (May) and highest in August (December). The recent running average trend of annual anomalies of surface (deep) salinity is negative (negative).

3.3 DENSITY

[Table 3; Figures 4, 47]
Weekly norms of density at 1m and 5m are strongly correlated ($r = 0.74$), and slightly less correlated for those at 1m and 10m ($r = 0.50$). Monthly norms of surface (deep) density are lowest in September (September) and highest in March (April). The recent running average trend of annual anomalies of surface (deep) density is negative (negative).

3.4 STRATIFICATION

[Table 3; Figure 5]
Monthly norms of stratification are lowest in March and highest in September. The recent running average trend of annual anomalies of stratification is near normal.

3.5 OXYGEN

[Table 4; Figures 6, 7, 48, 49]
Weekly norms of oxygen concentration at 5m and 60m are strongly correlated ($r = 0.78$), as are the weekly norms of oxygen saturation at 5m and 60m ($r = 0.87$). Monthly norms of 5m (60m) oxygen saturation are lowest in December (December) and

highest in April (April). The recent running average trend of annual anomalies of 5m (60m) oxygen saturation is near normal (positive).

3.6 PAR ATTENUATION

[Table 5; Figure 8]
Monthly norms of PAR attenuation are lowest in January and highest in March. The recent running average trend of annual anomalies of PAR attenuation is near negative.

3.7 NITRATE

[Table 6; Figures 9, 50]
Weekly norms of nitrate at 1m and 5m are almost perfectly correlated ($r = 0.998$), as are those at 1m and 10m ($r = 0.983$). Monthly norms of surface (deep) nitrate are lowest in July (June) and highest in January (January). The recent running average trend of annual anomalies of surface (deep) nitrate is near normal (negative).

3.8 SILICATE

[Table 7; Figures 10, 51]
Weekly norms of silicate at 1m and 5m are almost perfectly correlated ($r = 0.989$), as are those at 1m and 10m ($r = 0.963$). Monthly norms of surface (deep) silicate are lowest in July (April) and highest in January (December). The recent running average trend of annual anomalies of surface (deep) silicate is near normal (negative).

3.9 PHOSPHATE

[Table 8; Figures 11, 52]
Weekly norms of phosphate at 1m and 5m are almost perfectly correlated ($r = 0.991$), as are those at 1m and 10m ($r = 0.963$). Monthly norms of surface (deep) phosphate are lowest in July (April) and highest in January (September). The recent running average trend of annual anomalies of surface (deep) phosphate is negative (negative).

3.10 AMMONIUM

[Table 9; Figures 12, 53]
Weekly norms of ammonium at 1m and 5m are almost perfectly correlated ($r = 0.951$), but those at 1m and 10m are less correlated ($r = 0.59$). Monthly norms of surface (deep) ammonium are lowest in July (February) and highest in November (July). The recent running average trend of annual anomalies of surface (deep) ammonium is positive (negative).

3.11 POC and PON

[Table 10; Figures 13, 14, 54, 55]
Weekly norms of POC at 5m and 60m are correlated ($r = 0.51$), as are the weekly norms of PON at 5m and 60m ($r = 0.72$). Monthly norms of 5m (60m) POC and PON are lowest in January (February) and highest in June (July). The recent running average trend of annual anomalies of 5m (60m) POC and PON are near normal (positive).

3.12 BACTERIA

[Table 11; Figures 15, 56]
Weekly norms of bacteria at 1m and 5m are almost perfectly correlated ($r = 0.996$), as are those at 1m and 10m ($r = 0.981$). Monthly norms of surface (deep) bacteria are lowest in January (February) and highest in July (July). The recent running average trend of annual anomalies of surface (deep) bacteria is negative (negative).

3.13 CHLOROPHYLL *a*

[Table 12; Figures 16, 57]
The quantity reported in this section is determined by fluorometric assay and is therefore analytically independent of the quantity determined by HPLC analysis (Section 3.19.4).

Weekly norms of Chl*a* at 1m and 5m are strongly correlated ($r = 0.91$), and less strongly correlated for those at 1m and 10m ($r = 0.71$). Monthly norms of surface Chl*a* indicate a primary bloom in spring (March) and a secondary bloom in fall (September). Monthly norms of deep Chl*a* are highest in April, one month following the surface spring bloom. The recent running average trend of annual anomalies of surface (deep) Chl*a* is positive (positive).

3.14 *SYNECHOCOCCUS*

[Table 13; Figures 17, 18]
Weekly norms of *Synechococcus* at 5m increase 929-fold (from 73 to 68148 cells ml^{-1}) over a 15-week period (from week 22 to 37), indicating a net doubling of the population in about 1.5 weeks. This period of net increase coincides exactly with the period during which the concentration of nitrate at 5m is less than about 0.5 mmol m^{-3}. In other words, *Synechococcus* decreases both during nitrate draw-down in spring, and during nitrate recharge in fall. It seems that *Synechococcus* starts to increase once nitrate falls

below the threshold from above, and it starts to decrease once nitrate rises above the threshold from below.

Monthly norms of *Synechococcus* at 5m are lowest in May; they are highest in September, coinciding with the fall bloom of Chl*a*. The recent running average trend of annual anomalies of *Synechococcus* is positive.

3.15 PICOEUKARYOTES

[Table 13; Figure 19]
Weekly norms of picoeukaryotes at 5m increase 27-fold (from 1515 to 40254 cells ml^{-1}) over a 25-week period (from week 7 to 32), indicating a net doubling of the population in about 5.3 weeks. Monthly norms of picoeukaryotes at 5m are lowest in February and are highest in August. The recent running average trend of annual anomalies of picoeukaryotes is positive.

3.16 PICOPHYTOPLANKTON

[Table 13; Figure 20]
Picophytoplankton is the sum of *Synechococcus* (Section 3.14) and picoeukaryotic algae (Section 3.15). Weekly norms of picophytoplankton at 5m increase 52-fold (from 1848 to 96667 cells ml^{-1}) over a 30-week period (from week 7 to 37), indicating a net doubling of the population in about 5.3 weeks. Monthly norms of picophytoplankton at 5m are lowest in February and are highest in September. The recent running average trend of annual anomalies of picophytoplankton is positive.

3.17 CRYPTOPHYTES

[Table 13; Figure 21]
Weekly norms of cryptophytes at 5m increase 6.7-fold (from 189 to 1268 cells ml^{-1}) over a 34-week period (from week 1 to 35), indicating a net doubling of the population in about 12.4 weeks. Monthly norms of cryptophytes at 5m are lowest in January and are highest in August. The recent running average trend of annual anomalies of cryptophytes is positive.

3.18 NANOPHYTOPLANKTON

[Table 13; Figure 22]
Weekly norms of nanophytoplantkon at 5m increase 12.8-fold (from 1489 to 19077 cells ml^{-1}) over a 34-week period (from week 1 to 35), indicating a net doubling of the population in about 9.2 weeks. Monthly norms of nanophytoplankton at 5m are lowest

in January and are highest in August. The recent running average trend of annual anomalies of nanophytoplankton is positive.

3.19 PHYTOPLANKTON PIGMENTS

In this section, we use Roy et al. (2011) as our reference monograph on phytoplankton pigments, especially the chapters by Jeffrey et al. (2011) on microalgal classes and their signature pigments, and by Higgins et al. (2011) on the quantitative interpretation of chemotaxonomic pigment data.

3.19.1 19'-Butanoyloxyfucoxanthin

[Table 14; Figure 23]
The xanthophyll 19'-butanoyloxyfucoxanthin is dominant in Dictyophyceae and Pelagophyceae; it is significant but not always present in Prymnesiophyceae; and it is minor or variable in Dinophyceae.

Weekly norms of but-fuco at 1m and 5m are correlated (r = 0.77), as are those at 1m and 10m (r = 0.55). Monthly norms of surface (average 1, 5, and 10m) but-fuco are lowest in February and highest in August. The recent running average trend of annual anomalies of surface but-fuco is positive.

3.19.2 19'-Hexanoyloxyfucoxanthin

[Table 15; Figure 24]
The xanthophyll 19'-hexanoyloxyfucoxanthin is dominant in Prymnesiophyceae and Dinophyceae.

Weekly norms of hex-fuco at 1m and 5m are correlated (r = 0.74), as are those at 1m and 10m (r = 0.59). Monthly norms of surface (average 1, 5, and 10m) hex-fuco are lowest in February and highest in August. The recent running average trend of annual anomalies of surface hex-fuco is negative.

3.19.3 Alloxanthin

[Table 16; Figure 25]
The xanthophyll alloxanthin is dominant in Cryptophyta, including cryptophycean symbionts of the ciliate *Myrionecta rubra*. Alloxanthin also occurs in some dinoflagellates, and has been reported in 2 chlorophytes that show no evidence of a cryptomonad endosymbiont.

Weekly norms of alloxanthin at 5m and 10m are correlated (r = 0.75), but those at 1m and 10m are not correlated (r = 0.04). Monthly norms of surface (average 1, 5, and

10m) alloxanthin are lowest in March and highest in August. The recent running average trend of annual anomalies of surface alloxanthin is near normal.

3.19.4 Chlorophyll a

[Table 17; Figure 26]
Chlorophyll *a* is universal pigment found in all taxa. The quantity reported in this section is determined by HPLC analysis, and is therefore analytically independent from the quantity reported in Section 3.13

Weekly norms of Chl*a* at 1m and 5m are strongly correlated ($r = 0.87$), and slightly less correlated for those at 1m and 10m ($r = 0.59$). Monthly norms of surface (average 1, 5, and 10m) Chl*a* indicate a primary bloom in spring (March) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface Chl*a* is positive.

3.19.5 Chlorophyll b

[Table 18; Figure 27]
Chlorophyll *b* is dominant in the green algal lineage – Chlorophyceae, Prasinophyceae, Trebouxiophyceae, Mesostigmatophyceae, Euglenophyceae, and Chlorarachniophyceae.

Weekly norms of Chl*b* at 5m and 10m are correlated ($r = 0.82$), but those at 1m and 10m are not correlated ($r = 0.16$). Monthly norms of surface (average 1, 5, and 10m) Chl*b* indicate a primary bloom in spring (April) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface Chl*b* is positive.

3.19.6 Chlorophyll c

[Table 19; Figure 28]
Chlorophyll *c* occurs in the red algal lineage. Chlorophyll c_1+c_2 is dominant and widespread across 4 divisions (Heterokontophyta, Haptophyta, Cryptophyta, Dinophyta) with a distribution in 11 classes (Bacillariophyceae, Chrysophyceae, Dictyochophyceae, Pelagophyceae, Phaeothamniophyceae, Raphidophyceae, Synurophyceae, Pavlovophyceae, Prymnesiophyceae, Cryptophyceae, and Dinophyceae). Chlorophyll c_3 is dominant in Bacillariophyceae, Bolidophyceae, Prymnesiophyceae, and Dinophyceae; the pigment is significant but not always present in Dictyophyceae and Pelagophyceae.

Weekly norms of Chl*c* at 1m and 5m are strongly correlated ($r = 0.94$), and slightly less correlated for those at 1m and 10m ($r = 0.73$). Monthly norms of surface (average

1, 5, and 10m) Chl*c* indicate a primary bloom in spring (March) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface Chl*c* is slightly negative or near normal.

3.19.7 Diadinoxanthin

[Table 20; Figure 29]

The xanthophyll diadinoxanthin is dominant in Bacillariophyceae, Bolidophyceae, Dictyochophyceae, Pelagophyceae, Phaeothamniophyceae, Pavlovophyceae, Prymnesiophyceae, Dinophyceae, and Euglenophyceae. It is a minor pigment in Xanthophyceae.

Weekly norms of diadinoxanthin at 1m and 5m are correlated (r = 0.75), and slightly less correlated for those at 1m and 10m (r = 0.52). Monthly norms of surface (average 1, 5, and 10m) diadinoxanthin indicate a primary bloom in spring (March) with levels sustained fairly high till fall (September). The recent running average trend of annual anomalies of surface diadinoxanthin is slightly negative or near normal.

3.19.8 Fucoxanthin

[Table 21; Figure 30]

The xanthophyll fucoxanthin is dominant and widespread in Bacillariophyceae, Bolidophyceae, Chrysophyceae, Dictyochophyceae, Pelagophyceae, Phaeothamniophyceae, Pinguiophyceae, Raphidophyceae, Synurophyceae, Pavlovophyceae, Prymnesiophyceae, and Dinophyceae.

Weekly norms of fucoxanthin at 1m and 5m are strongly correlated (r = 0.95), and slightly less correlated for those at 1m and 10m (r = 0.80). Monthly norms of surface (average 1, 5, and 10m) fucoxanthin indicate a primary bloom in spring (March) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface fucoxanthin is near normal.

3.19.9 Peridinin

[Table 22; Figure 31]

Peridinin is a diagnostic marker for dinoflagellates.

Weekly norms of peridinin at 1m and 5m are strongly correlated (r = 0.95), and less correlated for those at 1m and 10m (r = 0.54). Monthly norms of surface (average 1, 5, and 10m) peridinin are lowest in January and highest in October. The recent running average trend of annual anomalies of surface peridinin is near normal.

3.19.10 Zeaxanthin

[Table 23; Figure 32]
The xanthophyll zeaxanthin is widespread in cyanobacteria, and also present in the classes of the green lineage – Prasinophyceae, Chlorophyceae, Trebouxiophyceae, and Chlorarachniophyceae.

Weekly norms of zeaxanthin at 1m and 5m are strongly correlated ($r = 0.96$), and slightly less correlated for those at 1m and 10m ($r = 0.85$). Monthly norms of surface (average 1, 5, and 10m) zeaxanthin are lowest in February and highest in September. The recent running average trend of annual anomalies of surface zeaxanthin is positive.

3.19.11 Diagnostic Pigments

[Table 24; Figure 33]
The weighted sum of diagnostic pigments (DiagPig) is a quasi-measure of total phytoplankton chlorophyll *a*. This quasi-measure is based on the weighted contribution of 7 phytoplankton pigments used as chemotaxonomic markers for constituent members of the phytoplankton community. In principle, the salient patterns of DiagPig should corroborate those of Chl*a* (Section 3.19.4). However, because we have not tuned the Uitz global formula with weighting factors derived from local calibration, the comparison between DiagPig and Chl*a* cannot be taken as a validation exercise. Notwithstanding the lack of calibration, because Fuco occurs at high concentrations in these waters, and also because Fuco is weighted heavily in the Uitz global formula, it can be deduced that the results of DiagPig and Fuco are necessarily similar in pattern. These deductions are confirmed.

Weekly norms of DiagPig at 1m and 5m are strongly correlated ($r = 0.88$), and less correlated for those at 1m and 10m ($r = 0.63$). Monthly norms of surface (average 1, 5, and 10m) DiagPig indicate a primary bloom in spring (March) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface DiagPig is near normal.

3.19.12 Microphytoplankton Pigments

[Table 25; Figure 34]
MicroPig is the weighted sum of fucoxanthin and peridinin (Section 2.1).

Weekly norms of MicroPig at 1m and 5m are strongly correlated ($r = 0.94$), and less correlated for those at 1m and 10m ($r = 0.69$). Monthly norms of surface (average 1, 5, and 10m) MicroPig indicate a primary bloom in spring (March) and a secondary bloom in fall (September). The recent running average trend of annual anomalies of surface MicroPig is near normal.

3.19.13 Nanophytoplankton Pigments

[Table 26; Figure 35]

NanoPig is the weighted sum of but-fuco, hex-fuco, and alloxanthin (Section 2.1).

Weekly norms of NanoPig at 1m and 5m are correlated (r = 0.81), and less correlated for those at 1m and 10m (r = 0.60). Monthly norms of surface (average 1, 5, and 10m) NanoPig are lowest in February and highest in August. The recent running average trend of annual anomalies of surface NanoPig is slightly negative.

3.19.14 Picophytoplankton Pigments

[Table 27; Figure 36]

PicoPig is the weighted sum of Chl$b$ and zeaxanthin (Section 2.1).

Weekly norms of PicoPig at 5m and 10m are correlated (r = 0.81), but those at 1m and 10m are not correlated (r = 0.17). Monthly norms of surface (average 1, 5, and 10m) PicoPig are highest in April and remain high till September. The recent running average trend of annual anomalies of surface PicoPig is positive.

3.19.15 f-Microphytoplankton Pigments

[Table 28; Figure 37]

f-Micro is the fraction of diagnostic pigments assigned to the microphytoplankton size class.

Weekly norms of f-Micro at 1m and 5m are correlated (r = 0.84), and less correlated for those at 1m and 10m (r = 0.57). Monthly norms of surface (average 1, 5, and 10m) f-Micro are high ($\geq$66%) throughout the year, with a maximum value of 89% in March. The recent running average trend of annual anomalies of surface f-Micro is near normal.

3.19.16 f-Nanophytoplankton Pigments

[Table 29; Figure 38]

f-Nano is the fraction of diagnostic pigments assigned to the nanophytoplankton size class.

Weekly norms of f-Nano at 1m and 5m are strongly correlated (r = 0.90), and less correlated for those at 1m and 10m (r = 0.58). Monthly norms of surface (average 1, 5, and 10m) f-Nano are low ($\leq$20%) throughout the year, with a minimum value of 4% in March. The recent running average trend of annual anomalies of surface f-Nano is slightly negative.

3.19.16 f-Picophytoplankton Pigments

[Table 30; Figure 39]
f-Pico is the fraction of diagnostic pigments assigned to the picophytoplankton size class.

Weekly norms of f-Pico at 1m and 5m are correlated ($r = 0.71$), and considerably less correlated for those at 1m and 10m ($r = 0.44$). Monthly norms of surface (average 1, 5, and 10m) f-Pico are low ($\leq$17%) throughout the year, with a minimum value of 3.5% in February. The recent running average trend of annual anomalies of surface f-Pico is positive.

3.20 PHYTOPLANKTON LIGHT ABSORPTION

[Table 31; Figures 40, 41, 42, 43, and 44]
In Bedford Basin, as elsewhere, the spectral shape of the phytoplankton absorption coefficient is strongly determined by pigment packaging (which is related to cell size) and concentration of accessory pigments. Spectra for assemblages dominated by microphytoplankton are flatter than those dominated by nanophytoplankton, which in turn are flatter than those dominated by picophytoplankton (Ciotti et al. 2002). The weekly norms of absorption spectra (Figure 40) are most flat in the early and late weeks of the year, and least flat in the middle weeks of the year.

Weekly norms of phytoplankton absorption of blue light at 443 nm, $a_{ph}(443)$ are almost perfectly correlated with absorption of red light at 656 nm, $a_{ph}(656)$ at 1m depth ($r = 0.97$); the correlation of $a_{ph}(443)$ with absorption of green light, $a_{ph}(555)$ is also very strong, but less than perfect ($r = 0.92$).

Monthly norms of phytoplankton absorption at all 3 wavelengths are lowest in January and highest in September. The green:blue ratio [$a_{ph}(555)$: $a_{ph}(443)$] is low (0.16) in April, May, June, and July.

The pigment-specific absorption coefficients [$a^*_{ph}(\lambda)$], which are values of absorption divided by HPLC-determined Chl*a*, are lowest during the spring bloom in March. The norms[11] in March are $a^*_{ph}(443) = 0.023$, $a^*_{ph}(555) = 0.005$, and $a^*_{ph}(676) = 0.013$. The average ± sd of the monthly norms are $a^*_{ph}(443) = 0.037 \pm 0.006$, $a^*_{ph}(555) = 0.008 \pm 0.002$, and $a^*_{ph}(676) = 0.016 \pm 0.002$.

The time series for phytoplankton absorption are too short to delineate meaningful multiyear trends.

[11] Units are[m^2 (mg Chl*a*)$^{-1}$]

3.21 ANNUAL CYCLES

[Figure 58, 59]
Normal (climatological) annual cycles of physical, chemical, and biological variables in Bedford Basin typify the canonical model of spring-autumn blooms on mid-latitude continental shelves in the coastal domain (Longhurst 1995). General characteristics of the normal state of Bedford Basin have been previously described (Li and Dickie 2001; Li and Harrison 2008), but a new cluster heat map of z-standardised variables (Figure 58) highlights statistical associations between variables at an unprecedented level of detail for this system.

The phenomenological start of the spring bloom can be discerned between week 9 and week 10. At this time, there is a coherent increase in Chl*a*, Chl*b*, Chl*c*, fucoxanthin, diadinoxanthin, 19'-butanoyloxyfucoxanthin, microphytoplankton pigments, PAR attenuation, $a_{ph}(443)$, $a_{ph}(555)$, $a_{ph}(676)$, POC and PON. At the same time, there is a coherent decrease in nitrate, silicate and phosphate, when both temperature and stratification are just starting to rise from their annual low values. The peak of the spring bloom is normally attained on week 12, which is the time of spring equinox.

During several weeks immediately leading to the fall equinox (week 39), temperature and stratification reach their annual maxima, and so do *Synechococcus*, picoeukaryotes, cryptophytes, nanophytoplankton, zeaxanthin, and 19'-hexanoyloxyfucoxanthin. At this time, nutrients are all starting to rise above their summer low values. Indeed, as noted earlier (Section 3.14), the start and stop triggers for annual growth of *Synechococcus* in summer appears to be a critical concentration of nitrate.

Following the fall equinox, for about 8 weeks, as stratification starts to weaken and nutrients rise considerably above limiting concentrations, there is continuing persistence of Chl*a*, Chl*c*, diadinoxanthin, fucoxanthin, and alloxanthin. Notably, this is a period of increase for peridinin (dinoflagellate biomarker), which reaches its annual maximum on week 46.

Bivariate phase plots for a subset of the variables show seasonal hysteresis in many of the relationships, meaning that few of them represent mathematical functions that map a single output to a given input. Exceptions exist: some are expected by deduction, for example the input/output pairs of Chl*a*/fucoxanthin, and temperature/stratification; however, others are less easily ascribed to axiomatic principles, such as temperature/picoeukaryotes, nitrate/nanophytoplankton, nitrate/bacteria, and perhaps nanophytoplankton/picoeukaryotes.

3.22 MULTIYEAR TRENDS

[Figures 60, 61, 62]
In analysing the first 14 years of this time series, Li and Harrison (2008) noted that annual average anomalies in stratification explain significant amounts of variability in the anomalies of bulk phytoplankton biomass, especially that contributed by diatoms, but not the biomass of picophytoplankton. Instead, the responses of the small phytoplankton appear directly related to temperature.

More recently, the surface layer has become still warmer, still fresher, and still less dense. At the same time, the deep layer has also become warmer, fresher, and less dense – effectively attenuating the increase of stratification anomaly. Notwithstanding this attenuation, inter-annual change in stratification remains anti-coherent with surface salinity and surface density. As a consequence of these recent changes, positive anomalies in variables related to picoplankton (*Synechococcus*, picoeukaryotes, zeaxanthin, Chl*b*) remain coherent with higher surface temperatures. Similarly, negative anomalies in variables related to microplankton (fucoxanthin, diadinoxanthin, Chl*c*) remain coherent with lower surface salinity and density.

Bivariate phase plots for a subset of the annual average variables show that some parts of the system exhibit trajectories that have now carried those parts substantially away from their starting positions first occupied at the beginning of the time series. For example, the input/output pairs of temperature/picoeukaryotes and temperature/*Synechococcus* both have trajectories that are directed from low/low values to high/high values – and therefore this is also the case with the picoeukaryotes/*Synechococcus* pair. On the other hand, the input/output pair of phosphate/bacteria is on a trajectory from high/high values to low/low values.

4. DISCUSSION

4.1 SCIENTIFIC METHOD

This report presents a detailed evidentiary record of microbial plankton and their environment in the Bedford Basin from 1992 to 2013. It provides information on microbes that is supplementary to annual data of the core program reported to the Canadian Science Advisory Secretariat (Johnson et al. 2013). In this respect, the microbial data broaden BBMP ecosystem considerations to include all size classes of the phytoplankton and also the prokaryotic secondary producers. Amongst the small number of long-term oceanographic observation programs in the world carried out in

support of ecosystem assessment and management, BBMP is one of the very few that includes direct measurements in explicit recognition of the new microbial paradigm (now 40-years old) of the ocean's food web (Pomeroy 1974).

Towards meeting the expressed goals and objectives of BBMP (Section 1.1), we offer in this report the multidisciplinary data sets that can be used to establish relationships among the organismal (phytoplankton and bacteria), chemotaxonomic (diagnostic pigments), bio-optical (light absorption), chemical (nutrients and oxygen), and physical (temperature, salinity, stratification) variables. We use the method of hierarchical coarse-graining to progressively enlarge the scale of analysis to discern macroscopic pattern (Li and López-Urrutia 2013). Starting at the grain scale of a week, we progressively average over months and years. Phytoplankton and bacterioplankton interact at the short scales of microbial generation times which are below the detection capabilities of BBMP; but temporal averaging to increasingly large scales allows the detection of climate-related signals (Li et al. 2006; Li 2009).

Notwithstanding the relatively short length of the time series, the relationships amongst variables presented in this report offer insight on putative changes in the state of the Bedford Basin. However, we note carefully that phenomenological ecology offers, at best, circumstantial evidence which corroborates one particular alternative hypothesis, but does not and cannot constitute a strong test of a null hypothesis (Strong 1980). Essentially, in ecological systems, causes are usually neither severally necessary nor jointly sufficient for their effects (Hull 1974). This means that although we may be able to explain (in statistical form), we may not always be able to predict. This is an ineluctable constraint.

4.2 SYSTEM STATE

Given an insufficient understanding of systems based on holistic theory, a framework for understanding marine ecosystem health has been developed using the pragmatic alternative of a state space approach (Tett et al. 2013). The following definitions undergird this framework. A *system* is a set of elements standing in interrelation among themselves and with their environment. A *state variable* is a quantification of a system property. The *state* of the system is given by a single set of values of a set of state variables sufficient to specify the system's condition uniquely. *State space* is the *n*-dimensional space of possible locations of state variables. *Trajectory* is a temporal sequence of system states plotted in state space. *Regime* is a coherent bundle of trajectories, such as those arising from seasonal cycles. *Domain* is a region in state space. *Basin of attraction* is a region in state space in which the system tends to remain. *Variability* in state space has three components: semi-cyclical (e.g. associated with seasonal cycles and classed as part of the organisation); medium-term (about a trend);

and long-term (i.e. a trend). *Organisation* is the types and arrangements or interconnections of the components of a system.

Here in this report, we can see the alignment of BBMP to the framework. The physical, chemical, and biological *system* of the Bedford Basin is quantified by a set of many *state variables* (although not all independent). A portion of the *state space* is now described in detail (Figure 59), showing seasonal *trajectories* that partially delineate the *domain* of the normal *state* of the system, which has an *organisation* of interconnected seasonal *variability* (Figure 58), reflecting a *regime* where temperature, stratification, and nutrients bundle biological trajectories in coherent manner (Figure 63A), or otherwise into a putatively different *basin of attraction* (Figure 64A). For the phytoplankton and bacteria system in Bedford Basin, the results of the monitoring program give a good description of the reference state for understanding ecosystem health.

4.3 SYSTEM CHANGE

System change can be tracked by the departure of annual means from their reference state, and if the departures lead increasingly to a greater cumulative difference from the reference state, then a long-term trend is indicated. A system that is subject to the forcing from earth orbit around the sun is more-or-less reset to its initial state on a 12-month period. Therefore, even for a 12-month trajectory that is far-ranging over phase space (which is the usual case for variables of temperate coastal environments), the trajectory tends to return close to its starting position after 12 months. On the other hand, unlike the entirely predictable annual orbital cycle, we are not aware of any regular phenomenon that might predictably drive system trajectories on a multiyear basis in Bedford Basin, at least from 1992 to 2013. In this latter regard, annual-based trajectories are not predictably constrained; where they end may give a clue as to the forces that led them there (Figures 63, 64).

In one part of the Bedford Basin system, there is evidence of a long-term increase in the abundance of both picoeukaryotes and *Synechococcus*. The phase trajectory of the 2 taxa is not a straight line from 1993 to 2013 (Figure 63B), but the long-term trend is clearly discernible in spite of medium-term variability. What is the proximate driver of this annual change? Principal component analysis indicates that changes in picophytoplankton are strongly coherent with changes in temperature and stratification; strongly anti-coherent with changes in diatom-related markers (fucoxanthin, diadinoxanthin); and not strongly coherent with nutrients (Figure 60). In the absence of time series information on other important parts of the ecosystem (such as nanozooplankton, microzooplankton, mesozooplankton, viruses, micronutrients, or vitamins), any assignment of putative cause to observed effect can only be provisional.

Therefore, based on only the circumstantial evidence collected, a probabilistic explanation for the long-term trend of picophytoplankton is positive forcing by identified coherent system properties and/or negative forcing by identified anti-coherent system properties.

In another part of the Bedford Basin system, there is suggestive evidence that the annual-based trajectory of phosphate/bacteria has recently shifted to a substantially different portion of the phase space (Figure 64B). Unlike the month-based trajectory of phosphate/bacteria that moves from high/low to low/high (January to June), and then from low/high back to high/low (July to December), the annual-based trajectory has moved in the opposite direction from high/high (1993) to low/low (2013). Clearly, different underlying processes must be implicated in the different time scales. The attraction of one annual-based trajectory to a different centre, that is to say a variables-shift, is a necessary but not sufficient condition for a regime-shift. The latter, by definition, requires a bundle of such trajectories moving coherently to the new centre of attraction. It is possible that PAR attenuation (Figure 8) has a similar trajectory, thus putatively making a bundle of two. A plausible but untested circumstantial explanation for the state shift is the influence of advanced-primary treatment on municipal wastewater discharged into Halifax Harbour[12], which started in February 2008, was interrupted in January 2009, and brought back to full operation in June 2010[13].

4.4 IMPLICATIONS

Long-term change in marine ecosystems is driven by a hierarchy of nested processes that cascade from global to hemispheric to regional to local scales. Further, in nearshore coastal ecosystems, the forcings from ocean, land, and atmosphere intersect and interact (Cloern and Jassby 2008; Cloern et al. 2014). Long-term change cannot be tracked and understood without observational time series nested in a spatial network of monitoring sites. To this end, the oceanographic and ecological measurements presented in this report on Bedford Basin, and the companion reports on the Scotian Shelf (Li 2014) and the Labrador Sea (Li and Harrison 2014) together constitute an integrated collection from which we can examine the state of the ocean at various scales of time and space. Theorists point out that as we coarse-grain a fractal system to higher hierarchical levels (e.g. Figures 63, 64), there is an inevitable gain in entropy according to the second law of thermodynamics (Baranger, undated). In a curious way, it is paradoxical that gaining knowledge about the long term first requires gaining knowledge about the short term, and then purposefully forgoing it.

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[12] http://www.halifax.ca/harboursol/documents/HHWQMPFinalSummaryReport.pdf

[13] http://www.halifax.ca/harboursol/HSPTimeline-1749toPresent.php;

In its normal (climatological) state, the microbial plankton system in Bedford Basin is well-described (Figures 58, 59) and usefully understood in the context of seasonal cycles of pelagic production and consumption (Longhurst 1995). Nonetheless, there is still much to be revealed as system components are further examined by other methods of reductionistic analysis. For example, the community of bacteria (which we only considered in bulk in this report) can be distinguished by gene analysis as various assemblages of co-occurring bacteria that exhibit strong seasonal preferences and associations with particular phytoplankton taxa (El-Swais et al. 2014). As another example, identification of peptide sequences by mass spectrometry to examine protein expression patterns can be used to study seasonal progression of microbial metabolic activity (Georges et al. 2014).

However, it is in its long-term trajectory that the Bedford Basin system is most informative of future ecosystem health. The Compass Buoy Station is the inshore terminus of the AZMP Halifax Line which extends seaward onto the Scotian Shelf. It is perhaps not surprising that the system appears to have characteristics indicating both local and regional trends. On the one hand, the recent state of low bacteria and low phosphate seems to be a local trend. On the other hand, the continuing increase of picophytoplankton seems to be a trend that is shared with systems at other locations on the Scotian Shelf (Li 2014). To date, these regional changes of picophytoplankton seem to be confined to the normal basin of system attraction. Only time and continued observation will tell if these systems have enough latitude to resist a regime shift, or whether they are precariously close to losing their resilience. Any ensuing impact on ecosystem health will need to be assessed according to whether the system retains, inter alia, adequate functional diversity and functional response diversity. Evidence to test these conjectures lie beyond the scope of this report.

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TABLE 1

YEAR	(All)	TEMPERATURE (Celsius)

	Data			
WEEK	TMPR_01m	TMPR_05m	TMPR_10m	TMPR_60m
1	3.53	3.91	4.35	4.93
2	3.16	3.69	4.14	4.74
3	2.66	2.77	3.10	4.61
4	2.10	2.51	2.80	4.81
5	1.47	1.89	2.34	4.60
6	1.24	1.49	1.79	4.61
7	0.96	1.35	1.45	4.08
8	1.14	1.27	1.55	3.82
9	1.17	1.32	1.39	3.61
10	1.30	1.44	1.41	3.31
11	1.79	1.65	1.61	2.67
12	2.13	1.81	1.60	2.49
13	2.20	1.82	1.65	2.13
14	3.06	2.37	1.91	1.87
15	3.59	2.72	2.16	1.95
16	4.16	2.93	2.17	1.96
17	6.10	4.05	2.95	1.97
18	5.81	4.24	3.03	1.83
19	6.81	5.29	3.55	1.91
20	7.95	5.90	4.20	1.93
21	9.04	6.49	4.62	2.00
22	9.66	6.80	4.87	1.95
23	10.60	7.41	5.42	2.08
24	11.41	8.17	6.23	2.30
25	12.77	9.31	7.21	2.19
26	14.48	10.59	8.33	2.23
27	14.83	9.76	7.46	2.37
28	15.47	10.77	8.35	2.29
29	15.32	10.94	8.34	2.29
30	16.88	12.07	9.20	2.54
31	17.09	12.28	9.70	2.43
32	17.32	13.04	10.12	2.45
33	16.79	12.58	9.72	2.41
34	16.71	12.65	10.09	2.49
35	16.07	12.96	10.27	2.46
36	15.69	13.84	11.86	2.61
37	15.78	14.09	12.25	2.80
38	15.15	13.82	11.96	2.94
39	14.60	13.78	12.23	3.10
40	14.34	13.80	12.59	3.36
41	12.89	12.61	11.61	3.36
42	11.74	11.59	10.95	4.09
43	10.88	10.95	10.51	4.01
44	9.85	9.99	9.83	3.96
45	8.98	9.20	9.18	4.07
46	8.41	8.60	8.53	4.39
47	7.61	8.38	8.58	4.33
48	6.74	7.21	7.54	4.50
49	6.51	6.87	7.11	4.69
50	5.45	5.92	6.31	4.60
51	4.69	5.18	5.46	4.45
52	3.97	4.63	4.98	4.44
53	3.51	3.66	4.07	3.86
Grand Total	8.72	7.30	6.34	3.13

TABLE 2

YEAR	(All)

SALINITY (psu)

	Data			
WEEK	SALI_01m	SALI_05m	SALI_10m	SALI_60m
1	29.51	29.70	30.15	31.41
2	28.92	29.51	30.08	31.38
3	29.80	29.95	30.26	31.37
4	29.57	29.89	30.18	31.36
5	29.31	29.81	30.15	31.20
6	28.93	29.86	30.30	31.35
7	29.59	30.06	30.27	31.28
8	29.02	30.00	30.30	31.24
9	29.08	29.92	30.29	31.21
10	29.06	29.90	30.28	31.19
11	29.06	29.85	30.37	31.04
12	29.29	30.07	30.40	31.10
13	29.40	30.16	30.40	31.11
14	28.35	29.94	30.37	31.11
15	28.56	29.89	30.35	31.10
16	28.51	29.93	30.51	31.15
17	28.74	29.93	30.51	31.14
18	28.52	29.96	30.48	31.10
19	28.34	29.78	30.43	31.12
20	28.18	29.69	30.33	31.10
21	28.14	29.76	30.32	31.10
22	28.46	29.89	30.44	31.11
23	28.61	30.08	30.52	31.12
24	28.57	30.03	30.49	31.12
25	28.69	29.80	30.28	31.11
26	28.86	30.06	30.43	31.13
27	29.05	30.26	30.61	31.12
28	29.11	30.29	30.63	31.13
29	29.35	30.24	30.60	31.14
30	29.08	30.35	30.73	31.11
31	29.35	30.44	30.72	31.13
32	29.06	30.29	30.63	31.10
33	29.42	30.37	30.66	31.11
34	29.60	30.49	30.73	31.09
35	29.79	30.44	30.72	31.09
36	29.65	30.32	30.56	31.10
37	29.59	30.19	30.50	31.12
38	29.13	30.06	30.48	31.12
39	29.73	30.17	30.57	31.13
40	29.20	29.82	30.25	31.15
41	29.24	29.94	30.38	31.18
42	29.35	29.91	30.39	31.26
43	29.10	29.76	30.23	31.28
44	28.95	29.66	30.14	31.31
45	29.07	29.56	30.16	31.31
46	28.81	29.69	30.13	31.35
47	28.37	29.43	29.98	31.32
48	28.79	29.70	30.13	31.35
49	28.44	29.29	29.87	31.35
50	28.96	29.64	30.11	31.39
51	29.24	29.80	30.08	31.36
52	28.62	29.71	30.10	31.33
53	29.12	29.81	30.11	31.38
Grand Total	29.03	29.95	30.36	31.19

TABLE 3

YEAR	(All)	DENSITY (kg/m3)			
		STRATIFICATION (kg/m4)			
	Data				
WEEK	DENSITY_01m	DENSITY_05m	DENSITY_10m	DENSITY_60m	STRATFCTN
1	23.45	23.57	23.89	24.83	0.0216
2	23.03	23.45	23.86	24.83	0.0249
3	23.75	23.87	24.08	24.83	0.0168
4	23.61	23.84	24.05	24.80	0.0169
5	23.44	23.82	24.07	24.70	0.0167
6	23.14	23.88	24.21	24.82	0.0185
7	23.69	24.05	24.21	24.81	0.0144
8	23.23	24.01	24.24	24.81	0.0174
9	23.27	23.94	24.23	24.80	0.0160
10	23.26	23.92	24.22	24.81	0.0179
11	23.23	23.87	24.29	24.74	0.0170
12	23.38	24.03	24.31	24.80	0.0160
13	23.46	24.11	24.31	24.84	0.0152
14	22.57	23.89	24.27	24.86	0.0228
15	22.69	23.82	24.23	24.85	0.0226
16	22.60	23.84	24.36	24.88	0.0235
17	22.61	23.76	24.31	24.87	0.0227
18	22.45	23.76	24.27	24.86	0.0242
19	22.15	23.50	24.18	24.86	0.0278
20	21.93	23.37	24.05	24.85	0.0310
21	21.76	23.37	24.02	24.85	0.0320
22	21.88	23.43	24.08	24.86	0.0309
23	21.88	23.50	24.09	24.85	0.0308
24	21.68	23.37	23.98	24.83	0.0332
25	21.57	23.01	23.68	24.84	0.0370
26	21.31	23.02	23.66	24.85	0.0401
27	21.42	23.30	23.92	24.83	0.0355
28	21.37	23.22	23.83	24.85	0.0371
29	21.52	23.09	23.79	24.85	0.0389
30	21.00	23.03	23.83	24.81	0.0398
31	21.21	23.04	23.70	24.84	0.0387
32	20.92	22.77	23.52	24.81	0.0437
33	21.28	22.86	23.58	24.82	0.0402
34	21.43	22.95	23.57	24.80	0.0388
35	21.73	22.85	23.53	24.80	0.0387
36	21.69	22.58	23.12	24.80	0.0427
37	21.63	22.41	23.03	24.79	0.0423
38	21.41	22.38	23.06	24.78	0.0454
39	21.97	22.45	23.04	24.78	0.0416
40	21.61	22.21	22.77	24.77	0.0453
41	21.93	22.52	23.04	24.80	0.0427
42	22.24	22.69	23.18	24.79	0.0374
43	22.17	22.68	23.13	24.81	0.0388
44	22.26	22.78	23.19	24.84	0.0378
45	22.48	22.83	23.31	24.83	0.0365
46	22.36	23.02	23.38	24.83	0.0355
47	22.12	22.84	23.25	24.81	0.0376
48	22.54	23.21	23.50	24.83	0.0315
49	22.28	22.93	23.35	24.80	0.0350
50	22.84	23.32	23.64	24.84	0.0281
51	23.14	23.53	23.72	24.84	0.0250
52	22.71	23.51	23.78	24.82	0.0273
53	23.16	23.69	23.90	24.91	0.0242
Grand Total	22.30	23.29	23.77	24.82	0.0305

TABLE 4

YEAR	(All)	OXYGEN CONCENTRATION (ml/l)		
		OXYGEN SATURATION (%)		
	Data			
WEEK	OXY-CONC_05m	OXY-SAT_05m	OXY-CONC_60m	OXY-SAT_60m
1	7.26	96	2.60	36
2	6.91	91	2.99	41
3	7.37	96	3.09	38
4	7.60	98	3.16	44
5	7.52	95	2.89	39
6	7.86	99	3.03	41
7	8.26	103	3.43	46
8	8.39	105	3.68	49
9	8.89	111	4.22	55
10	8.81	111	4.61	64
11	9.05	114	5.70	73
12	8.78	108	4.92	68
13	8.99	114	6.53	83
14	9.37	119	7.24	88
15	9.32	121	6.85	87
16	9.32	121	7.29	93
17	9.57	129	7.50	95
18	9.09	123	7.23	92
19	8.78	121	7.55	96
20	8.81	123	7.22	92
21	8.69	122	7.00	90
22	8.45	119	6.72	86
23	8.65	124	6.89	88
24	8.94	128	6.45	85
25	7.93	120	6.32	81
26	8.00	124	6.35	81
27	7.86	119	5.85	75
28	7.42	114	5.50	71
29	8.08	123	5.15	66
30	6.95	110	5.03	64
31	7.49	118	5.09	65
32	7.09	113	4.57	59
33	7.31	116	4.41	57
34	6.95	112	3.93	51
35	6.99	116	3.90	50
36	6.37	106	3.53	46
37	6.56	107	3.56	47
38	6.84	114	3.24	43
39	6.66	110	3.54	48
40	6.19	106	3.67	45
41	5.96	97	3.38	50
42	6.24	99	3.79	52
43	6.09	95	3.47	51
44	6.16	94	3.47	48
45	6.40	96	3.38	46
46	6.41	96	3.65	50
47	6.12	91	2.85	39
48	6.59	95	2.78	38
49	6.18	89	2.74	41
50	6.17	86	2.66	36
51	6.22	86	2.35	32
52	7.12	97	2.34	31
53	7.28	96	1.48	19
Grand Total	7.59	109	4.64	61

TABLE 5

YEAR	(All)	PAR ATTENUATION (m^{-1})

	Data
WEEK	PAR ATTEN
1	0.252
2	0.248
3	0.257
4	0.287
5	0.252
6	0.233
7	0.295
8	0.288
9	0.255
10	0.367
11	0.389
12	0.426
13	0.366
14	0.433
15	0.373
16	0.314
17	0.345
18	0.323
19	0.315
20	0.357
21	0.345
22	0.370
23	0.329
24	0.340
25	0.316
26	0.348
27	0.318
28	0.323
29	0.352
30	0.339
31	0.343
32	0.352
33	0.348
34	0.342
35	0.327
36	0.312
37	0.338
38	0.326
39	0.326
40	0.301
41	0.296
42	0.329
43	0.267
44	0.312
45	0.288
46	0.315
47	0.282
48	0.274
49	0.269
50	0.286
51	0.253
52	0.272
53	0.306
Grand Total	0.318

TABLE 6

YEAR	(All)

NITRATE (mmol/m3)

	Data			
WEEK	NITRA_01m	NITRA_05m	NITRA_10m	NITRA_60m
1	8.06	7.74	7.97	17.40
2	8.25	8.21	8.04	16.84
3	7.37	7.37	7.42	17.64
4	7.45	7.40	7.32	17.33
5	7.76	7.67	7.67	17.88
6	7.14	6.93	6.92	18.01
7	7.23	7.04	7.05	16.17
8	6.77	6.66	6.91	15.77
9	5.95	5.72	6.23	15.81
10	4.66	4.71	5.48	14.30
11	4.24	4.06	5.31	12.52
12	2.08	2.61	4.56	11.42
13	2.10	2.14	3.90	9.72
14	1.81	1.63	3.25	9.43
15	1.32	1.30	2.45	9.33
16	1.32	1.30	2.54	8.22
17	1.08	0.87	1.74	8.10
18	1.10	0.81	1.66	7.66
19	1.09	0.80	1.23	7.95
20	1.02	0.68	1.03	8.26
21	1.12	0.75	1.00	8.29
22	0.47	0.49	0.80	8.54
23	0.57	0.50	0.78	7.29
24	0.43	0.37	0.59	7.70
25	0.52	0.39	0.60	8.21
26	0.36	0.29	0.61	8.47
27	0.33	0.35	0.65	8.71
28	0.31	0.32	0.73	9.90
29	0.24	0.25	0.48	9.31
30	0.20	0.24	0.50	10.68
31	0.29	0.22	0.66	10.35
32	0.26	0.29	0.72	10.32
33	0.19	0.25	0.92	10.26
34	0.14	0.20	0.87	10.58
35	0.23	0.27	0.84	10.49
36	0.30	0.30	0.81	11.65
37	0.18	0.23	0.84	11.20
38	0.44	0.45	1.08	11.63
39	0.58	0.67	1.34	12.93
40	0.86	0.74	1.25	13.69
41	1.24	1.14	1.83	13.09
42	1.77	1.72	2.47	13.02
43	1.97	2.10	2.97	13.13
44	3.12	3.02	3.52	13.31
45	3.58	3.68	4.41	14.60
46	4.21	3.94	4.52	13.82
47	4.56	4.25	4.46	15.55
48	5.52	5.21	5.25	16.82
49	6.53	5.71	5.89	16.11
50	7.00	6.60	6.68	16.68
51	7.73	7.35	7.31	17.09
52	7.33	7.03	7.16	16.89
53	7.88	7.85	7.81	20.15
Grand Total	2.88	2.80	3.29	12.21

TABLE 7

YEAR	(All)	SILICATE (mmol/m3)

	Data			
WEEK	SILI_01m	SILI_05m	SILI_10m	SILI_60m
1	10.84	10.32	10.24	30.98
2	11.14	10.82	10.44	29.49
3	10.01	9.83	9.66	30.83
4	9.92	9.61	9.33	30.05
5	10.94	10.31	10.14	33.09
6	10.27	9.47	9.27	33.15
7	9.59	8.94	8.87	28.69
8	9.35	8.88	8.89	28.00
9	8.42	7.49	7.81	27.77
10	6.88	6.37	6.92	24.10
11	6.28	5.28	6.71	20.14
12	3.37	3.29	5.46	17.78
13	3.14	2.75	4.40	14.26
14	3.47	2.60	3.44	14.30
15	3.04	2.48	3.14	13.13
16	2.74	2.09	2.53	11.82
17	3.20	2.15	1.99	11.42
18	3.17	2.05	2.47	11.85
19	3.61	2.21	2.39	12.48
20	3.44	2.31	2.15	13.90
21	3.59	2.27	2.58	14.45
22	2.63	2.33	2.86	15.43
23	2.64	2.23	2.97	15.11
24	2.66	2.12	2.70	15.93
25	2.52	2.14	2.63	17.17
26	1.94	1.67	2.97	18.21
27	1.43	2.38	2.59	18.30
28	0.67	1.32	2.48	21.47
29	0.65	0.99	2.34	21.11
30	0.52	0.96	2.33	23.17
31	0.41	0.75	2.32	23.61
32	1.14	1.17	2.40	24.33
33	0.72	1.14	2.69	25.36
34	0.59	1.12	2.96	26.18
35	0.89	1.58	3.25	27.30
36	1.75	1.69	2.97	28.25
37	1.68	2.06	3.58	29.41
38	2.41	2.32	3.74	29.46
39	1.89	2.06	3.99	30.88
40	2.40	1.99	3.05	30.53
41	3.67	2.97	4.46	31.13
42	3.97	3.55	4.73	28.43
43	4.25	4.24	4.83	28.46
44	5.61	5.28	5.57	30.27
45	6.19	5.57	6.23	31.44
46	7.10	6.11	6.43	27.76
47	7.74	7.13	6.79	32.44
48	8.80	8.00	7.59	33.18
49	10.28	8.35	8.32	32.19
50	10.40	9.24	8.81	32.54
51	10.63	9.74	9.29	34.32
52	10.57	9.37	9.26	29.13
53	11.01	10.85	10.68	34.01
Grand Total	4.91	4.49	5.10	24.12

TABLE 8

YEAR	(All)	PHOSPHATE (mmol/m3)		

	Data			
WEEK	PHOS_01m	PHOS_05m	PHOS_10m	PHOS_60m
1	1.20	1.18	1.25	4.59
2	1.24	1.22	1.20	4.22
3	1.11	1.12	1.15	4.24
4	1.10	1.14	1.12	4.37
5	1.16	1.15	1.16	4.88
6	1.11	1.08	1.11	4.13
7	1.06	1.07	1.11	3.56
8	1.04	1.07	1.11	3.41
9	0.96	1.01	1.11	3.34
10	0.86	0.94	1.02	3.36
11	0.75	0.82	1.00	2.47
12	0.60	0.74	0.96	2.25
13	0.64	0.70	0.92	1.98
14	0.55	0.64	0.86	1.88
15	0.53	0.61	0.78	1.80
16	0.49	0.53	0.75	1.63
17	0.46	0.53	0.72	1.83
18	0.47	0.52	0.73	1.85
19	0.47	0.52	0.70	1.92
20	0.42	0.52	0.65	1.96
21	0.45	0.55	0.72	2.08
22	0.36	0.46	0.66	2.30
23	0.37	0.49	0.64	2.21
24	0.36	0.47	0.60	2.51
25	0.39	0.47	0.60	2.67
26	0.40	0.47	0.61	2.89
27	0.35	0.43	0.63	3.02
28	0.32	0.44	0.66	3.43
29	0.32	0.44	0.65	3.63
30	0.31	0.45	0.63	3.88
31	0.31	0.42	0.68	3.95
32	0.36	0.51	0.72	4.09
33	0.35	0.60	0.75	3.92
34	0.36	0.51	0.76	3.98
35	0.42	0.57	0.76	4.02
36	0.47	0.54	0.74	4.30
37	0.46	0.57	0.78	4.10
38	0.48	0.56	0.81	4.30
39	0.61	0.62	0.85	4.49
40	0.50	0.56	0.74	4.78
41	0.63	0.65	0.84	4.89
42	0.72	0.75	0.90	4.47
43	0.68	0.75	0.89	4.22
44	0.80	0.82	0.92	4.13
45	0.84	0.88	0.98	4.17
46	0.86	0.93	1.02	3.63
47	0.93	0.93	0.94	4.17
48	0.99	0.97	0.98	4.26
49	0.98	1.00	1.01	4.36
50	1.03	1.02	1.02	4.20
51	1.17	1.10	1.13	4.42
52	1.13	1.08	1.13	3.99
53	1.22	1.18	1.14	4.04
Grand Total	0.67	0.73	0.87	3.46

TABLE 9

YEAR	(All)	AMMONIUM (mmol/m3)

	Data			
WEEK	AMMO_01m	AMMO_05m	AMMO_10m	AMMO_60m
1	4.25	3.88	3.10	1.47
2	4.07	3.24	2.48	1.91
3	4.09	3.29	2.82	1.10
4	3.42	2.86	2.60	1.64
5	5.39	3.03	2.80	1.76
6	3.65	3.10	2.83	0.52
7	3.25	2.92	2.78	1.43
8	2.40	2.05	2.09	0.83
9	2.41	2.03	2.03	1.22
10	1.55	1.39	1.67	1.31
11	1.87	1.23	1.63	1.75
12	1.49	0.85	1.43	1.54
13	1.17	0.87	1.57	1.94
14	1.02	0.85	1.19	2.32
15	1.63	0.83	1.52	2.67
16	1.79	0.95	1.41	3.06
17	1.72	1.14	1.58	4.52
18	1.49	0.76	1.80	5.38
19	1.83	1.46	1.55	6.01
20	2.16	1.37	1.99	7.01
21	1.98	1.40	2.07	7.79
22	1.18	1.59	2.19	10.74
23	1.54	1.41	2.52	12.10
24	1.58	1.35	1.80	14.51
25	2.70	1.79	2.52	14.62
26	1.32	1.46	3.74	14.35
27	1.14	0.62	1.91	14.73
28	0.82	0.82	2.05	14.64
29	0.50	0.51	1.19	14.83
30	0.55	1.08	1.78	14.67
31	0.56	0.53	2.27	14.76
32	0.59	0.82	2.43	14.82
33	0.54	0.70	2.37	15.22
34	0.54	0.97	3.73	13.89
35	0.51	0.75	2.28	14.83
36	0.83	0.99	2.51	13.14
37	0.63	0.76	2.81	12.40
38	0.64	0.81	2.19	10.42
39	1.17	1.66	3.62	8.22
40	2.06	2.03	3.31	6.95
41	3.22	3.38	4.57	7.73
42	3.26	3.11	4.88	7.27
43	4.01	3.89	5.50	7.03
44	4.45	3.70	4.30	6.80
45	3.86	3.74	4.03	6.05
46	4.19	3.98	4.38	5.60
47	6.26	4.96	4.22	5.40
48	5.82	4.73	4.15	2.91
49	5.83	4.62	3.88	3.77
50	5.73	3.69	3.14	3.39
51	3.69	3.23	2.85	4.08
52	3.70	3.13	2.69	2.39
53	2.62	2.57	2.32	0.71
Grand Total	2.42	2.04	2.71	7.27

TABLE 10

YEAR	(All)	POC, PON (mg/m3)

	Data			
WEEK	POC_05m	PON_05m	POC_60m	PON_60m
1	215	27	182	20
2	203	27	172	19
3	210	28	196	20
4	238	32	200	20
5	242	32	175	16
6	271	40	149	17
7	323	47	152	16
8	405	65	143	17
9	438	73	130	16
10	698	114	168	19
11	739	118	176	22
12	738	122	200	30
13	680	107	226	36
14	762	128	202	28
15	787	137	189	30
16	600	99	208	32
17	763	133	194	30
18	756	132	180	29
19	669	121	249	40
20	697	125	209	31
21	760	134	191	29
22	950	163	198	29
23	956	164	221	32
24	967	159	249	34
25	784	141	299	45
26	1,158	183	314	41
27	978	158	323	41
28	736	123	313	40
29	951	151	327	49
30	890	146	321	44
31	984	144	396	51
32	900	147	314	45
33	872	138	293	43
34	905	136	258	38
35	918	143	271	39
36	879	134	255	37
37	983	149	245	34
38	934	148	241	34
39	802	130	275	37
40	782	125	212	29
41	690	113	246	32
42	713	113	219	30
43	773	120	263	36
44	507	82	181	24
45	616	95	183	23
46	536	82	190	21
47	391	63	190	24
48	369	56	208	25
49	299	43	200	22
50	250	36	218	25
51	255	38	240	29
52	339	46	317	32
53	265	42	315	31
Grand Total	662	107	227	30

TABLE 11

YEAR	(All)	BACTERIA (cells/ml)

	Data			
WEEK	BACT_01m	BACT_05m	BACT_10m	BACT_60m
1	867,594	768,272	791,217	731,421
2	857,469	782,948	782,521	724,559
3	694,766	664,670	669,612	693,339
4	894,238	795,365	769,049	662,544
5	845,783	784,589	707,097	719,018
6	836,484	731,867	666,544	661,827
7	814,981	772,868	741,316	655,741
8	812,954	715,225	735,141	670,881
9	1,113,113	1,007,607	1,006,403	754,445
10	988,149	948,109	863,696	687,096
11	1,184,819	1,018,346	965,648	698,444
12	1,223,552	1,112,815	1,028,165	742,006
13	1,326,682	1,211,725	1,062,547	778,096
14	1,458,837	1,347,762	1,258,392	808,450
15	1,589,091	1,398,206	1,169,681	872,908
16	1,749,572	1,586,096	1,329,987	1,048,876
17	1,917,983	1,756,740	1,635,316	1,071,251
18	1,526,713	1,460,321	1,369,535	1,050,202
19	1,630,374	1,478,336	1,340,955	996,044
20	1,937,715	1,681,640	1,491,858	970,616
21	2,292,491	1,768,229	1,621,386	931,571
22	2,255,493	1,974,143	1,569,761	904,923
23	2,335,964	1,883,867	1,668,823	924,511
24	3,696,980	2,872,244	2,008,951	925,691
25	4,307,230	3,736,912	2,509,106	935,012
26	5,185,675	4,391,726	2,851,431	975,391
27	4,432,850	3,699,246	2,469,469	1,091,365
28	4,231,678	3,792,005	2,740,597	1,050,053
29	4,156,329	3,330,479	2,477,766	930,201
30	3,298,805	2,743,470	2,034,033	1,201,510
31	3,461,841	2,956,561	2,006,481	1,023,969
32	3,764,621	2,904,158	1,988,522	1,137,399
33	3,651,261	3,100,827	1,966,011	1,085,532
34	3,325,053	2,803,894	2,182,605	1,012,815
35	3,423,394	2,599,886	2,194,086	939,154
36	3,648,986	2,918,358	2,411,276	956,027
37	3,040,840	2,640,334	1,838,895	937,802
38	2,948,550	2,570,180	1,892,026	915,595
39	2,783,576	2,369,623	1,893,538	841,679
40	2,239,965	1,871,148	1,402,855	758,431
41	1,880,721	1,641,211	1,392,233	755,524
42	1,863,395	1,580,536	1,387,806	787,734
43	1,714,498	1,510,148	1,253,588	810,154
44	1,781,369	1,550,723	1,345,783	735,978
45	1,359,676	1,199,352	1,074,234	756,491
46	1,421,302	1,257,307	1,185,904	918,191
47	1,222,222	1,123,356	1,041,085	701,826
48	1,303,704	1,137,824	1,121,529	764,967
49	1,301,243	1,070,848	1,011,906	800,265
50	1,033,831	921,697	912,969	754,274
51	942,621	856,631	842,095	773,694
52	1,002,853	895,971	887,665	704,521
53	902,996	771,769	718,063	566,287
Grand Total	2,139,206	1,819,108	1,471,356	864,449

TABLE 12

YEAR	(All)	CHLOROPHYLL *a* (mg/m3)

	Data			
WEEK	CHL_01m	CHL_05m	CHL_10m	CHL 60m
1	1.41	1.39	0.92	0.07
2	2.19	2.15	0.83	0.06
3	3.12	3.11	2.61	0.07
4	2.84	4.04	3.35	0.10
5	1.18	1.37	1.06	0.07
6	3.59	3.82	3.51	0.06
7	2.67	3.53	2.97	0.11
8	4.56	5.77	4.51	0.24
9	5.71	6.61	5.18	0.18
10	9.08	10.67	7.65	0.40
11	9.93	11.50	8.04	0.72
12	10.65	11.39	7.41	1.14
13	9.00	9.84	7.40	1.26
14	8.69	9.96	8.38	1.03
15	6.74	7.96	6.07	0.94
16	4.14	5.13	5.13	0.76
17	5.44	7.57	5.62	0.79
18	3.95	6.79	5.41	0.44
19	4.51	5.63	5.53	0.44
20	3.93	5.38	5.49	0.30
21	4.26	6.09	4.49	0.30
22	4.55	5.76	5.17	0.27
23	5.51	7.39	5.72	0.24
24	5.16	6.10	5.01	0.37
25	4.96	5.44	3.58	0.44
26	6.96	6.68	4.35	0.42
27	4.84	5.31	6.21	0.94
28	4.37	5.18	4.22	0.70
29	4.89	6.61	6.92	0.79
30	5.73	6.10	5.09	0.85
31	5.98	6.77	5.88	0.67
32	6.53	13.11	5.28	0.87
33	5.58	7.45	4.03	0.59
34	5.64	7.55	4.36	0.49
35	6.35	6.91	4.70	0.42
36	6.87	8.47	5.09	0.31
37	8.31	10.81	6.44	0.58
38	7.86	9.85	5.04	0.33
39	8.64	8.83	3.99	0.19
40	8.28	8.27	4.37	0.30
41	6.83	7.12	3.15	0.28
42	7.98	7.69	4.10	0.36
43	8.27	7.90	3.75	0.33
44	6.01	5.89	3.90	0.37
45	9.07	8.08	3.12	0.39
46	8.69	7.79	3.78	0.18
47	5.63	5.48	3.99	0.25
48	3.51	3.38	2.44	0.20
49	2.52	2.33	1.95	0.28
50	1.63	1.73	1.11	0.10
51	1.32	1.52	1.05	0.09
52	1.64	1.65	0.88	0.09
53	2.10	1.31	0.79	0.05
Grand Total	5.57	6.43	4.46	0.43

TABLE 13

YEAR	(All)	PHYTOPLANKTON (cells/ml)			
	Data				
WEEK	SYNECHO-5m	PICOEUK-5m	PICOPHYTO-5m	CRYPTO-5m	NANOPHYTO-5m
1	1,349	3,533	4,882	189	1,489
2	1,025	3,444	4,469	164	1,510
3	883	2,697	3,580	190	1,579
4	652	2,548	3,200	340	1,782
5	487	1,751	2,238	311	1,424
6	423	1,832	2,255	278	1,414
7	332	1,515	1,848	299	1,707
8	280	1,918	2,199	398	2,298
9	289	1,715	2,004	340	2,533
10	248	2,055	2,303	270	4,434
11	269	3,224	3,493	337	5,522
12	242	1,880	2,122	353	5,226
13	243	2,039	2,282	441	5,810
14	318	2,532	2,851	251	5,962
15	141	2,904	3,045	587	4,622
16	137	3,929	4,066	305	3,815
17	114	3,489	3,603	486	4,443
18	200	3,239	3,439	403	6,339
19	109	3,561	3,664	839	7,939
20	79	5,660	5,739	408	8,437
21	143	9,625	9,760	907	8,049
22	73	12,830	12,896	714	15,153
23	130	20,585	20,715	453	18,111
24	148	16,030	16,178	542	11,589
25	835	17,765	18,558	513	10,045
26	341	14,660	15,000	449	10,162
27	954	19,411	20,365	624	13,724
28	3,196	25,119	28,315	734	9,242
29	4,397	23,909	28,306	988	19,341
30	6,086	25,866	31,951	462	16,122
31	16,643	30,108	46,751	542	12,591
32	24,780	40,254	65,035	827	12,644
33	21,929	27,650	49,579	967	16,426
34	26,534	30,694	57,229	808	17,386
35	46,490	28,565	75,055	1,268	19,077
36	58,279	26,873	85,152	1,129	17,717
37	68,148	28,519	96,667	980	17,068
38	55,982	28,812	84,794	769	14,991
39	60,286	20,479	80,764	1,039	11,906
40	36,184	14,212	50,396	652	8,638
41	25,430	11,314	36,743	659	8,138
42	22,868	9,123	31,991	673	6,749
43	21,167	10,107	31,274	499	4,954
44	21,806	13,522	35,328	352	4,354
45	9,240	7,596	16,836	420	4,051
46	7,304	8,550	15,855	346	2,558
47	7,859	6,408	14,267	272	2,489
48	8,337	8,330	16,270	215	2,711
49	5,031	6,647	11,678	194	2,338
50	3,352	5,333	8,684	222	1,744
51	2,620	4,203	6,823	194	1,403
52	1,334	3,611	4,945	366	1,414
53	805	3,414	4,219	134	895
Grand Total	11,095	11,855	22,884	517	7,709

TABLE 14

YEAR	(All)	19'-BUTANOYLOXYFUCOXANTHIN (mg/m3)

	Data			
WEEK	19BUT_01m	19BUT_05m	19BUT_10m	19BUT_60m
1	0.000	0.003	0.000	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000
10	0.009	0.000	0.007	0.000
11	0.025	0.020	0.015	0.000
12	0.032	0.020	0.014	0.003
13	0.017	0.014	0.014	0.008
14	0.017	0.023	0.005	0.003
15	0.010	0.007	0.007	0.000
16	0.017	0.010	0.006	0.000
17	0.037	0.042	0.013	0.004
18	0.011	0.024	0.004	0.001
19	0.015	0.021	0.003	0.002
20	0.021	0.007	0.008	0.000
21	0.012	0.008	0.007	0.000
22	0.070	0.036	0.000	0.000
23	0.025	0.011	0.017	0.000
24	0.065	0.015	0.009	0.000
25	0.051	0.023	0.015	0.000
26	0.051	0.036	0.018	0.000
27	0.061	0.042	0.013	0.000
28	0.020	0.013	0.030	0.000
29	0.052	0.051	0.009	0.000
30	0.059	0.042	0.034	0.000
31	0.112	0.162	0.026	0.000
32	0.062	0.061	0.044	0.000
33	0.104	0.065	0.002	0.000
34	0.052	0.054	0.024	0.001
35	0.068	0.031	0.006	0.000
36	0.046	0.060	0.011	0.000
37	0.045	0.037	0.014	0.000
38	0.035	0.014	0.003	0.000
39	0.002	0.002	0.000	0.004
40	0.011	0.004	0.002	0.000
41	0.032	0.034	0.003	0.000
42	0.021	0.034	0.027	0.000
43	0.077	0.058	0.037	0.004
44	0.010	0.015	0.007	0.000
45	0.072	0.017	0.010	0.000
46	0.002	0.066	0.000	0.006
47	0.007	0.007	0.008	0.000
48	0.032	0.013	0.000	0.000
49	0.001	0.007	0.000	0.000
50	0.002	0.000	0.000	0.000
51	0.000	0.000	0.000	0.000
52	0.001	0.001	0.001	0.000
53	0.000	0.000	0.000	0.000
Grand Total	0.029	0.023	0.009	0.001

TABLE 15

YEAR	(All)	19'-HEXANOYLOXYFUCOXANTHIN (mg/m3)

	Data			
WEEK	19HEX_01m	19HEX_05m	19HEX_10m	19HEX_60m
1	0.000	0.000	0.000	0.000
2	0.001	0.002	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000
9	0.001	0.000	0.000	0.000
10	0.000	0.000	0.000	0.003
11	0.002	0.003	0.000	0.003
12	0.039	0.034	0.033	0.006
13	0.005	0.044	0.065	0.014
14	0.021	0.049	0.041	0.015
15	0.076	0.158	0.065	0.017
16	0.042	0.124	0.073	0.008
17	0.036	0.318	0.100	0.007
18	0.038	0.346	0.172	0.012
19	0.011	0.031	0.074	0.005
20	0.023	0.028	0.043	0.002
21	0.043	0.028	0.044	0.000
22	0.081	0.071	0.030	0.001
23	0.117	0.109	0.071	0.001
24	0.039	0.063	0.035	0.003
25	0.096	0.065	0.027	0.000
26	0.081	0.054	0.020	0.000
27	0.349	0.147	0.029	0.000
28	0.165	0.103	0.015	0.002
29	0.141	0.112	0.036	0.005
30	0.138	0.098	0.023	0.001
31	0.139	0.082	0.026	0.000
32	0.214	0.145	0.079	0.006
33	0.204	0.152	0.038	0.000
34	0.367	0.318	0.127	0.000
35	0.291	0.247	0.106	0.000
36	0.278	0.266	0.112	0.000
37	0.297	0.223	0.119	0.000
38	0.215	0.217	0.096	0.000
39	0.205	0.148	0.056	0.000
40	0.244	0.195	0.060	0.003
41	0.188	0.157	0.042	0.000
42	0.154	0.079	0.039	0.015
43	0.049	0.038	0.012	0.000
44	0.024	0.036	0.013	0.000
45	0.026	0.028	0.009	0.000
46	0.009	0.013	0.001	0.003
47	0.012	0.020	0.016	0.000
48	0.014	0.015	0.003	0.000
49	0.014	0.013	0.001	0.000
50	0.014	0.007	0.004	0.013
51	0.007	0.005	0.000	0.000
52	0.002	0.003	0.000	0.000
53	0.000	0.000	0.000	0.000
Grand Total	0.088	0.085	0.038	0.004

TABLE 16

YEAR	(All)	ALLOXANTHIN (mg/m3)

	Data			
WEEK	ALLOX_01m	ALLOX_05m	ALLOX_10m	ALLOX_60m
1	0.11	0.11	0.07	0.00
2	0.23	0.23	0.05	0.00
3	0.26	0.21	0.07	0.00
4	0.08	0.31	0.15	0.00
5	0.36	0.23	0.10	0.00
6	0.07	0.14	0.10	0.01
7	0.04	0.17	0.16	0.01
8	0.07	0.23	0.15	0.00
9	0.06	0.14	0.15	0.00
10	0.09	0.17	0.09	0.00
11	0.06	0.14	0.08	0.00
12	0.06	0.14	0.11	0.00
13	0.04	0.18	0.11	0.00
14	0.11	0.15	0.10	0.00
15	0.11	0.18	0.16	0.00
16	0.05	0.11	0.19	0.00
17	0.07	0.13	0.18	0.00
18	0.09	0.20	0.22	0.00
19	0.08	0.23	0.30	0.00
20	0.14	0.34	0.26	0.00
21	0.10	0.39	0.35	0.01
22	0.11	0.25	0.32	0.02
23	0.19	0.23	0.36	0.02
24	0.09	0.29	0.34	0.04
25	0.20	0.35	0.37	0.02
26	0.33	0.53	0.33	0.03
27	0.32	0.39	0.25	0.06
28	0.10	0.33	0.29	0.07
29	0.13	0.41	0.48	0.06
30	0.17	0.36	0.40	0.08
31	0.10	0.36	0.31	0.10
32	0.25	0.44	0.41	0.12
33	0.23	0.52	0.31	0.11
34	0.19	0.48	0.42	0.05
35	0.19	0.46	0.45	0.06
36	0.23	0.42	0.41	0.06
37	0.22	0.44	0.34	0.02
38	0.31	0.42	0.27	0.01
39	0.33	0.43	0.21	0.06
40	0.30	0.37	0.23	0.02
41	0.34	0.37	0.23	0.09
42	0.33	0.35	0.21	0.16
43	0.39	0.40	0.14	0.10
44	0.31	0.29	0.14	0.02
45	0.51	0.37	0.13	0.06
46	0.34	0.30	0.17	0.04
47	0.25	0.19	0.11	0.02
48	0.26	0.19	0.12	0.03
49	0.16	0.12	0.07	0.08
50	0.15	0.14	0.07	0.02
51	0.11	0.13	0.07	0.02
52	0.15	0.15	0.09	0.00
53	0.23	0.10	0.03	0.00
Grand Total	0.19	0.28	0.22	0.03

TABLE 17

YEAR	(All)	[HPLC] CHLOROPHYLL *a* (mg/m3)

	Data			
WEEK	CHLa_01m	CHLa_05m	CHLa_10m	CHLa_60m
1	1.84	1.71	1.31	0.10
2	1.76	2.09	0.95	0.06
3	2.07	2.11	1.57	0.09
4	1.16	2.29	1.56	0.11
5	2.61	2.23	1.23	0.09
6	1.31	1.94	1.27	0.05
7	1.71	2.84	2.18	0.07
8	3.42	4.30	3.15	0.20
9	4.19	5.63	4.94	0.13
10	6.24	7.43	6.01	0.31
11	7.16	9.49	5.86	0.64
12	7.93	9.36	6.32	1.11
13	7.07	7.24	6.94	1.28
14	5.39	6.19	5.82	1.04
15	5.82	7.59	5.20	0.85
16	3.30	4.59	4.91	0.62
17	3.69	6.57	5.55	0.49
18	3.30	7.04	5.33	0.36
19	2.80	3.96	4.65	0.32
20	4.11	5.21	4.40	0.34
21	2.75	4.68	5.00	0.29
22	4.22	4.50	4.38	0.27
23	5.39	6.39	6.06	0.25
24	3.47	4.57	4.38	0.37
25	4.97	5.35	4.06	0.24
26	6.12	7.12	3.64	0.32
27	7.21	6.50	4.79	0.65
28	3.53	5.25	4.19	0.56
29	4.65	5.64	5.49	0.41
30	5.13	5.00	5.97	0.61
31	4.16	5.95	4.51	0.80
32	5.43	5.51	4.55	0.68
33	4.78	5.80	3.50	0.57
34	5.00	5.83	3.65	0.35
35	5.91	6.08	3.95	0.24
36	6.32	6.29	4.37	0.24
37	6.58	6.72	4.29	0.20
38	6.68	7.01	4.07	0.14
39	7.73	7.28	3.79	0.21
40	6.68	6.45	3.77	0.20
41	6.60	6.44	3.50	0.77
42	6.25	5.32	2.50	1.59
43	7.33	5.97	2.36	0.89
44	6.11	5.64	3.41	0.60
45	6.92	5.93	2.15	0.92
46	7.15	7.47	3.68	0.54
47	6.00	4.14	3.48	0.28
48	3.25	2.70	2.25	0.27
49	2.46	1.97	1.40	0.42
50	1.68	1.48	0.88	0.08
51	1.31	1.23	0.91	0.09
52	1.53	1.51	1.22	0.06
53	1.41	0.90	0.36	0.06
Grand Total	4.66	5.16	3.78	0.44

TABLE 18

YEAR	(All)	CHLOROPHYLL *b* (mg/m3)

	Data			
WEEK	CHLb_01m	CHLb_05m	CHLb_10m	CHLb_60m
1	0.03	0.04	0.03	0.00
2	0.04	0.03	0.03	0.01
3	0.03	0.04	0.03	0.01
4	0.03	0.02	0.02	0.00
5	0.02	0.01	0.01	0.00
6	0.01	0.03	0.03	0.00
7	0.01	0.07	0.01	0.00
8	0.01	0.03	0.02	0.00
9	0.05	0.06	0.04	0.00
10	0.17	0.31	0.22	0.00
11	0.21	0.42	0.25	0.01
12	0.47	0.52	0.40	0.01
13	0.12	0.46	0.63	0.01
14	0.17	0.40	0.54	0.01
15	0.85	1.63	0.58	0.09
16	0.13	0.78	0.60	0.01
17	0.31	2.12	0.95	0.03
18	0.28	2.47	1.11	0.07
19	0.12	0.48	0.76	0.03
20	0.35	0.55	0.41	0.00
21	0.15	0.22	0.63	0.03
22	0.26	0.66	0.18	0.01
23	0.33	0.37	0.50	0.01
24	0.24	0.42	0.36	0.01
25	0.44	0.33	0.25	0.01
26	0.30	0.32	0.08	0.00
27	1.03	0.36	0.10	0.02
28	0.31	0.35	0.13	0.00
29	0.52	0.38	0.16	0.00
30	0.71	0.37	0.16	0.00
31	0.35	0.32	0.09	0.03
32	0.46	0.31	0.17	0.00
33	0.47	0.50	0.15	0.00
34	0.37	0.46	0.20	0.00
35	0.50	0.48	0.21	0.00
36	0.47	0.48	0.26	0.01
37	0.50	0.44	0.16	0.00
38	0.48	0.45	0.15	0.00
39	0.41	0.34	0.14	0.00
40	0.40	0.33	0.19	0.00
41	0.32	0.26	0.09	0.00
42	0.18	0.12	0.09	0.01
43	0.35	0.18	0.10	0.00
44	0.17	0.19	0.08	0.00
45	0.30	0.20	0.06	0.00
46	0.34	0.30	0.06	0.00
47	0.27	0.15	0.07	0.00
48	0.13	0.11	0.06	0.00
49	0.10	0.07	0.04	0.00
50	0.09	0.07	0.04	0.00
51	0.08	0.05	0.04	0.00
52	0.04	0.04	0.03	0.00
53	0.07	0.04	0.02	0.00
Grand Total	0.28	0.39	0.23	0.01

TABLE 19

YEAR	(All)	CHLOROPHYLL *c* (mg/m3)

	Data			
WEEK	CHLc_01m	CHLc_05m	CHLc_10m	CHLc_60m
1	0.18	0.16	0.10	0.01
2	0.21	0.23	0.09	0.01
3	0.22	0.23	0.15	0.04
4	0.11	0.26	0.15	0.05
5	0.35	0.27	0.13	0.02
6	0.14	0.21	0.14	0.00
7	0.23	0.34	0.27	0.00
8	0.54	0.70	0.49	0.04
9	0.66	0.84	0.66	0.01
10	1.13	1.33	0.95	0.04
11	1.32	1.72	0.92	0.09
12	1.43	1.59	0.97	0.14
13	1.29	1.31	0.99	0.19
14	1.24	1.27	0.93	0.15
15	0.83	0.98	0.64	0.10
16	0.67	0.71	0.61	0.09
17	0.64	0.56	0.56	0.06
18	0.54	0.56	0.50	0.04
19	0.44	0.48	0.49	0.04
20	0.58	0.57	0.51	0.03
21	0.37	0.51	0.41	0.03
22	0.65	0.69	0.48	0.03
23	0.73	0.99	0.78	0.01
24	0.54	0.59	0.53	0.04
25	0.75	0.85	0.50	0.02
26	0.94	0.96	0.45	0.03
27	0.91	0.90	0.77	0.06
28	0.54	0.63	0.56	0.04
29	0.63	0.83	0.76	0.03
30	0.69	0.67	0.87	0.05
31	0.73	0.96	0.62	0.12
32	0.87	0.82	0.65	0.07
33	0.71	0.77	0.45	0.05
34	0.78	0.87	0.53	0.03
35	0.86	0.87	0.51	0.04
36	0.98	0.96	0.66	0.04
37	1.06	1.01	0.63	0.02
38	0.88	1.01	0.57	0.01
39	1.06	0.99	0.49	0.04
40	1.02	0.91	0.46	0.03
41	0.95	0.93	0.48	0.20
42	0.94	0.84	0.31	0.36
43	1.28	0.94	0.33	0.28
44	0.98	0.90	0.53	0.13
45	1.04	0.83	0.25	0.29
46	1.27	1.25	0.47	0.22
47	0.93	0.62	0.41	0.05
48	0.42	0.39	0.27	0.10
49	0.26	0.24	0.15	0.08
50	0.19	0.17	0.08	0.01
51	0.12	0.12	0.07	0.01
52	0.14	0.15	0.12	0.01
53	0.22	0.13	0.04	0.04
Grand Total	0.72	0.74	0.49	0.08

TABLE 20

YEAR	(All)	DIADINOXANTHIN (mg/m3)

	Data			
WEEK	DIADINO_01m	DIADINO_05m	DIADINO_10m	DIADINO_60m
1	0.04	0.03	0.02	0.00
2	0.03	0.03	0.02	0.00
3	0.02	0.03	0.03	0.01
4	0.03	0.03	0.02	0.01
5	0.04	0.04	0.02	0.01
6	0.04	0.05	0.02	0.00
7	0.07	0.10	0.05	0.00
8	0.15	0.17	0.10	0.01
9	0.16	0.20	0.13	0.00
10	0.34	0.37	0.21	0.01
11	0.47	0.46	0.23	0.02
12	0.45	0.47	0.28	0.04
13	0.40	0.40	0.31	0.05
14	0.36	0.41	0.27	0.04
15	0.46	0.60	0.23	0.04
16	0.22	0.35	0.24	0.02
17	0.29	0.72	0.28	0.02
18	0.24	0.70	0.34	0.02
19	0.20	0.23	0.21	0.01
20	0.30	0.26	0.16	0.00
21	0.30	0.22	0.13	0.01
22	0.39	0.32	0.10	0.01
23	0.54	0.45	0.22	0.00
24	0.44	0.29	0.12	0.01
25	0.58	0.34	0.10	0.00
26	0.53	0.42	0.14	0.00
27	0.48	0.30	0.11	0.01
28	0.36	0.25	0.08	0.00
29	0.37	0.28	0.12	0.00
30	0.46	0.30	0.21	0.00
31	0.60	0.47	0.15	0.02
32	0.46	0.27	0.15	0.00
33	0.44	0.30	0.09	0.01
34	0.57	0.42	0.14	0.00
35	0.57	0.39	0.14	0.00
36	0.50	0.38	0.16	0.01
37	0.61	0.43	0.15	0.01
38	0.51	0.49	0.17	0.00
39	0.49	0.39	0.11	0.00
40	0.43	0.36	0.12	0.01
41	0.38	0.33	0.10	0.05
42	0.37	0.30	0.10	0.11
43	0.54	0.30	0.09	0.05
44	0.28	0.26	0.14	0.02
45	0.38	0.27	0.07	0.04
46	0.45	0.23	0.11	0.04
47	0.40	0.22	0.11	0.01
48	0.11	0.11	0.06	0.01
49	0.07	0.07	0.04	0.01
50	0.05	0.03	0.01	0.01
51	0.02	0.02	0.02	0.00
52	0.03	0.03	0.02	0.00
53	0.04	0.02	0.01	0.00
Grand Total	0.33	0.29	0.13	0.02

TABLE 21

YEAR	(All)	FUCOXANTHIN (mg/m3)		
	Data			
WEEK	FUCO_01m	FUCO_05m	FUCO_10m	FUCO_60m
1	0.55	0.49	0.37	0.05
2	0.28	0.38	0.32	0.04
3	0.26	0.42	0.50	0.16
4	0.26	0.24	0.29	0.26
5	0.40	0.44	0.29	0.11
6	0.32	0.35	0.29	0.04
7	0.54	0.61	0.52	0.06
8	1.37	1.56	1.26	0.13
9	1.59	1.88	1.60	0.12
10	2.21	2.56	2.04	0.15
11	2.64	3.26	2.07	0.29
12	2.63	3.37	2.20	0.49
13	2.29	2.26	2.06	0.54
14	1.62	1.73	1.61	0.43
15	1.22	1.52	1.15	0.33
16	1.08	1.28	1.17	0.29
17	1.10	0.89	0.99	0.21
18	0.90	0.92	0.82	0.13
19	0.76	0.82	0.78	0.11
20	0.98	0.99	0.94	0.14
21	0.79	0.88	0.75	0.08
22	1.24	1.19	0.89	0.07
23	1.35	1.72	1.46	0.05
24	0.90	0.94	0.86	0.09
25	1.09	1.16	0.70	0.05
26	1.60	1.55	0.73	0.05
27	1.77	1.84	1.50	0.17
28	1.01	1.21	0.99	0.04
29	1.23	1.35	1.23	0.03
30	1.30	1.21	1.57	0.05
31	1.56	1.89	1.40	0.15
32	1.91	1.54	1.08	0.07
33	1.48	1.41	0.81	0.06
34	1.79	1.66	0.89	0.04
35	2.11	1.82	1.18	0.04
36	1.92	1.91	1.19	0.06
37	2.20	1.99	1.21	0.02
38	1.84	2.09	1.44	0.03
39	2.00	1.83	1.14	0.05
40	1.98	1.76	1.02	0.06
41	1.83	1.76	0.99	0.34
42	2.08	1.62	0.72	0.65
43	2.11	1.66	0.70	0.60
44	2.10	1.87	1.36	0.25
45	1.41	1.30	0.49	0.57
46	2.06	2.14	1.13	0.50
47	1.56	1.13	1.09	0.13
48	0.68	0.66	0.66	0.15
49	0.48	0.46	0.40	0.28
50	0.27	0.27	0.19	0.11
51	0.25	0.24	0.23	0.06
52	0.35	0.32	0.37	0.03
53	0.34	0.35	0.18	0.19
Grand Total	1.34	1.36	1.00	0.19

TABLE 22

YEAR	(All)	PERIDININ (mg/m3)

	Data			
WEEK	PERI_01m	PERI_05m	PERI_10m	PERI_60m
1	0.01	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.01	0.01	0.00	0.00
5	0.03	0.02	0.01	0.00
6	0.00	0.04	0.01	0.00
7	0.01	0.06	0.03	0.00
8	0.02	0.08	0.02	0.00
9	0.03	0.05	0.03	0.00
10	0.16	0.14	0.04	0.00
11	0.14	0.18	0.04	0.00
12	0.09	0.11	0.08	0.00
13	0.13	0.10	0.02	0.01
14	0.10	0.17	0.05	0.00
15	0.31	0.30	0.06	0.00
16	0.04	0.07	0.02	0.00
17	0.03	0.06	0.03	0.00
18	0.03	0.02	0.00	0.00
19	0.03	0.06	0.01	0.00
20	0.12	0.08	0.03	0.00
21	0.12	0.13	0.02	0.00
22	0.15	0.23	0.07	0.04
23	0.48	0.46	0.12	0.00
24	0.52	0.28	0.09	0.01
25	0.94	0.65	0.15	0.01
26	0.54	0.48	0.23	0.01
27	0.12	0.13	0.04	0.00
28	0.18	0.19	0.09	0.00
29	0.06	0.11	0.15	0.00
30	0.14	0.17	0.48	0.01
31	0.13	0.14	0.07	0.05
32	0.11	0.11	0.20	0.00
33	0.12	0.22	0.13	0.00
34	0.25	0.41	0.27	0.00
35	0.19	0.38	0.12	0.00
36	0.46	0.33	0.27	0.00
37	0.46	0.44	0.15	0.05
38	0.46	0.55	0.17	0.00
39	0.92	0.78	0.26	0.01
40	0.49	0.43	0.17	0.01
41	0.57	0.45	0.13	0.02
42	0.48	0.53	0.21	0.13
43	1.38	0.86	0.18	0.07
44	0.64	0.77	0.32	0.01
45	1.13	0.90	0.24	0.01
46	1.59	1.38	0.14	0.02
47	1.27	0.66	0.22	0.02
48	0.18	0.18	0.08	0.00
49	0.14	0.12	0.05	0.00
50	0.06	0.04	0.01	0.00
51	0.01	0.01	0.01	0.00
52	0.00	0.01	0.00	0.00
53	0.03	0.00	0.00	0.00
Grand Total	0.31	0.28	0.10	0.01

TABLE 23

YEAR	(All)	ZEAXANTHIN (mg/m3)

	Data			
WEEK	ZEA_01m	ZEA_05m	ZEA_10m	ZEA_60m
1	0.000	0.003	0.000	0.000
2	0.001	0.001	0.001	0.000
3	0.001	0.001	0.001	0.000
4	0.001	0.000	0.001	0.000
5	0.001	0.001	0.000	0.000
6	0.001	0.001	0.001	0.000
7	0.001	0.001	0.000	0.000
8	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000
10	0.002	0.001	0.000	0.000
11	0.009	0.011	0.006	0.000
12	0.009	0.012	0.012	0.004
13	0.010	0.015	0.022	0.012
14	0.010	0.014	0.020	0.010
15	0.012	0.017	0.013	0.009
16	0.016	0.008	0.012	0.007
17	0.017	0.014	0.014	0.004
18	0.015	0.014	0.007	0.000
19	0.020	0.025	0.016	0.000
20	0.018	0.013	0.010	0.000
21	0.025	0.021	0.011	0.000
22	0.021	0.009	0.007	0.001
23	0.046	0.022	0.011	0.002
24	0.038	0.037	0.024	0.005
25	0.044	0.040	0.027	0.000
26	0.033	0.024	0.011	0.000
27	0.079	0.047	0.021	0.000
28	0.049	0.037	0.016	0.005
29	0.061	0.045	0.022	0.003
30	0.079	0.048	0.033	0.003
31	0.038	0.033	0.017	0.000
32	0.053	0.037	0.017	0.000
33	0.050	0.039	0.016	0.001
34	0.056	0.038	0.020	0.000
35	0.064	0.059	0.017	0.002
36	0.057	0.055	0.029	0.000
37	0.095	0.090	0.029	0.000
38	0.079	0.067	0.029	0.000
39	0.055	0.040	0.028	0.000
40	0.062	0.047	0.016	0.001
41	0.037	0.032	0.017	0.000
42	0.031	0.016	0.011	0.005
43	0.019	0.012	0.007	0.004
44	0.009	0.012	0.006	0.000
45	0.032	0.010	0.004	0.000
46	0.010	0.007	0.005	0.001
47	0.008	0.006	0.002	0.000
48	0.007	0.006	0.002	0.003
49	0.003	0.005	0.001	0.000
50	0.002	0.002	0.002	0.000
51	0.001	0.001	0.000	0.000
52	0.000	0.001	0.000	0.000
53	0.000	0.000	0.000	0.000
Grand Total	0.027	0.021	0.012	0.002

TABLE 24

YEAR	(All)	DIAGNOSTIC PIGMENTS (mg/m3)		
	Data			
WEEK	DIAGPIG_01m	DIAGPIG_05m	DIAGPIG_10m	DIAGPIG_60m
1	0.88	0.80	0.59	0.08
2	0.59	0.72	0.52	0.07
3	0.57	0.76	0.77	0.24
4	0.46	0.56	0.53	0.36
5	0.84	0.80	0.49	0.16
6	0.51	0.66	0.52	0.05
7	0.81	1.12	0.88	0.09
8	2.02	2.48	1.92	0.19
9	2.38	2.87	2.42	0.17
10	3.57	4.23	3.21	0.22
11	4.19	5.37	3.29	0.42
12	4.41	5.59	3.74	0.71
13	3.58	3.98	3.74	0.82
14	2.70	3.26	3.03	0.65
15	3.19	4.53	2.49	0.60
16	1.82	2.92	2.51	0.43
17	2.01	3.99	2.65	0.34
18	1.72	4.40	2.64	0.26
19	1.31	1.92	2.17	0.19
20	2.03	2.33	2.00	0.20
21	1.58	1.95	2.01	0.15
22	2.44	2.94	1.76	0.18
23	3.22	3.75	3.04	0.10
24	2.41	2.44	1.97	0.17
25	3.61	3.22	1.74	0.10
26	3.67	3.61	1.67	0.09
27	4.43	3.61	2.50	0.29
28	2.31	2.70	1.87	0.11
29	2.68	2.89	2.46	0.09
30	3.10	2.72	3.37	0.14
31	3.05	3.61	2.40	0.36
32	3.80	3.14	2.36	0.18
33	3.20	3.36	1.73	0.16
34	3.90	4.12	2.28	0.09
35	4.30	4.23	2.47	0.10
36	4.39	4.30	2.73	0.13
37	4.87	4.51	2.46	0.12
38	4.27	4.76	2.74	0.06
39	5.03	4.50	2.34	0.12
40	4.44	3.93	2.10	0.12
41	4.19	3.84	1.88	0.55
42	4.22	3.49	1.60	1.23
43	5.61	4.05	1.45	1.01
44	4.26	4.15	2.54	0.39
45	4.28	3.58	1.17	0.86
46	5.71	5.50	1.95	0.76
47	4.44	2.82	2.01	0.23
48	1.53	1.44	1.18	0.23
49	1.10	0.99	0.72	0.45
50	0.67	0.60	0.36	0.19
51	0.52	0.49	0.42	0.10
52	0.63	0.59	0.61	0.04
53	0.74	0.59	0.29	0.27
Grand Total	2.87	3.00	1.98	0.32

TABLE 25

YEAR	(All)	MICROPHYTO PIGMENTS (mg/m3)		
	Data			
WEEK	MICROPIG_01m	MICROPIG_05m	MICROPIG_10m	MICROPIG_60m
1	0.78	0.70	0.52	0.08
2	0.41	0.55	0.46	0.06
3	0.38	0.60	0.70	0.22
4	0.39	0.35	0.42	0.36
5	0.60	0.65	0.42	0.16
6	0.46	0.55	0.42	0.05
7	0.78	0.94	0.77	0.09
8	1.96	2.32	1.81	0.18
9	2.29	2.73	2.29	0.17
10	3.34	3.81	2.94	0.21
11	3.92	4.85	2.97	0.41
12	3.83	4.92	3.21	0.69
13	3.41	3.33	2.93	0.78
14	2.43	2.67	2.35	0.60
15	2.15	2.56	1.71	0.47
16	1.59	1.90	1.68	0.40
17	1.59	1.34	1.43	0.30
18	1.31	1.32	1.16	0.18
19	1.11	1.23	1.11	0.15
20	1.55	1.52	1.37	0.20
21	1.29	1.43	1.09	0.12
22	1.97	2.01	1.35	0.15
23	2.57	3.08	2.22	0.08
24	2.01	1.72	1.34	0.13
25	2.87	2.55	1.20	0.08
26	3.02	2.87	1.35	0.08
27	2.66	2.77	2.18	0.24
28	1.67	1.98	1.52	0.06
29	1.83	2.06	1.95	0.05
30	2.02	1.94	2.89	0.08
31	2.39	2.87	2.07	0.28
32	2.85	2.32	1.81	0.10
33	2.26	2.30	1.33	0.09
34	2.88	2.92	1.63	0.06
35	3.23	3.10	1.83	0.07
36	3.36	3.16	2.06	0.08
37	3.75	3.42	1.92	0.11
38	3.25	3.72	2.27	0.05
39	4.12	3.68	1.98	0.08
40	3.49	3.09	1.67	0.10
41	3.39	3.12	1.58	0.50
42	3.61	3.04	1.31	1.10
43	4.92	3.55	1.23	0.95
44	3.86	3.72	2.36	0.37
45	3.59	3.10	1.02	0.82
46	5.14	4.97	1.79	0.73
47	3.99	2.53	1.84	0.22
48	1.21	1.19	1.05	0.21
49	0.88	0.82	0.64	0.40
50	0.47	0.43	0.27	0.16
51	0.36	0.35	0.34	0.09
52	0.49	0.46	0.53	0.04
53	0.53	0.49	0.25	0.27
Grand Total	2.33	2.30	1.56	0.28

TABLE 26

YEAR	(All)	NANOPHYTO PIGMENTS (mg/m3)

	Data			
WEEK	NANOPIG_01m	NANOPIG_05m	NANOPIG_10m	NANOPIG_60m
1	0.06	0.07	0.04	0.00
2	0.14	0.14	0.03	0.00
3	0.16	0.13	0.04	0.00
4	0.05	0.18	0.09	0.00
5	0.22	0.14	0.06	0.00
6	0.04	0.09	0.06	0.00
7	0.02	0.10	0.09	0.00
8	0.04	0.14	0.09	0.00
9	0.03	0.08	0.09	0.00
10	0.06	0.10	0.06	0.00
11	0.05	0.10	0.05	0.01
12	0.10	0.13	0.11	0.01
13	0.04	0.17	0.15	0.02
14	0.10	0.16	0.11	0.02
15	0.17	0.31	0.18	0.02
16	0.09	0.23	0.21	0.01
17	0.10	0.50	0.24	0.01
18	0.10	0.57	0.35	0.02
19	0.07	0.19	0.28	0.01
20	0.12	0.24	0.21	0.01
21	0.12	0.27	0.27	0.01
22	0.19	0.25	0.23	0.01
23	0.27	0.28	0.31	0.01
24	0.12	0.26	0.25	0.03
25	0.26	0.30	0.26	0.01
26	0.32	0.40	0.23	0.02
27	0.66	0.43	0.19	0.04
28	0.28	0.33	0.20	0.04
29	0.28	0.41	0.33	0.04
30	0.30	0.36	0.28	0.05
31	0.28	0.38	0.23	0.06
32	0.44	0.47	0.36	0.08
33	0.43	0.52	0.24	0.07
34	0.60	0.71	0.42	0.03
35	0.51	0.60	0.41	0.03
36	0.51	0.61	0.39	0.04
37	0.53	0.56	0.36	0.01
38	0.47	0.54	0.29	0.01
39	0.46	0.45	0.20	0.04
40	0.50	0.47	0.22	0.01
41	0.46	0.43	0.19	0.05
42	0.40	0.32	0.19	0.11
43	0.32	0.31	0.11	0.06
44	0.22	0.22	0.10	0.01
45	0.36	0.26	0.09	0.04
46	0.22	0.22	0.10	0.03
47	0.17	0.14	0.09	0.01
48	0.18	0.14	0.08	0.02
49	0.12	0.09	0.04	0.05
50	0.11	0.10	0.05	0.03
51	0.08	0.09	0.05	0.01
52	0.09	0.09	0.05	0.00
53	0.14	0.06	0.02	0.00
Grand Total	0.23	0.28	0.18	0.03

TABLE 27

YEAR	(All)	PICOPHYTO PIGMENTS (mg/m3)		
	Data			
WEEK	PICOPIG_01m	PICOPIG_05m	PICOPIG_10m	PICOPIG_60m
1	0.03	0.04	0.03	0.00
2	0.04	0.03	0.03	0.01
3	0.03	0.04	0.03	0.01
4	0.03	0.02	0.02	0.00
5	0.02	0.02	0.01	0.00
6	0.01	0.03	0.03	0.00
7	0.01	0.07	0.01	0.00
8	0.01	0.03	0.02	0.00
9	0.05	0.06	0.04	0.00
10	0.17	0.32	0.22	0.00
11	0.22	0.43	0.26	0.01
12	0.48	0.53	0.42	0.01
13	0.13	0.48	0.65	0.02
14	0.18	0.42	0.57	0.02
15	0.87	1.66	0.60	0.10
16	0.15	0.80	0.62	0.01
17	0.32	2.15	0.97	0.03
18	0.30	2.51	1.13	0.07
19	0.14	0.50	0.79	0.03
20	0.36	0.57	0.42	0.00
21	0.17	0.24	0.65	0.03
22	0.28	0.68	0.18	0.01
23	0.37	0.39	0.51	0.01
24	0.28	0.46	0.39	0.01
25	0.48	0.37	0.28	0.01
26	0.33	0.34	0.09	0.00
27	1.11	0.40	0.12	0.02
28	0.36	0.39	0.15	0.01
29	0.58	0.43	0.18	0.00
30	0.78	0.42	0.19	0.00
31	0.39	0.36	0.10	0.03
32	0.51	0.35	0.19	0.00
33	0.52	0.54	0.16	0.00
34	0.42	0.49	0.22	0.00
35	0.56	0.53	0.23	0.00
36	0.53	0.53	0.29	0.01
37	0.59	0.53	0.18	0.00
38	0.55	0.51	0.18	0.00
39	0.45	0.37	0.16	0.00
40	0.46	0.37	0.20	0.00
41	0.35	0.28	0.11	0.00
42	0.21	0.13	0.10	0.02
43	0.37	0.19	0.11	0.00
44	0.18	0.20	0.08	0.00
45	0.33	0.21	0.06	0.00
46	0.35	0.31	0.07	0.00
47	0.28	0.16	0.07	0.00
48	0.14	0.12	0.06	0.00
49	0.11	0.08	0.04	0.00
50	0.09	0.08	0.04	0.00
51	0.08	0.06	0.04	0.00
52	0.04	0.04	0.03	0.00
53	0.07	0.04	0.02	0.00
Grand Total	0.31	0.41	0.24	0.01

TABLE 28

YEAR	(All)	F-MICROPHYTO PIGMENTS (%)

	Data			
WEEK	FMICRO_01m	FMICRO_05m	FMICRO_10m	FMICRO_60m
1	0.70	0.69	0.71	0.75
2	0.64	0.67	0.75	0.94
3	0.71	0.70	0.71	0.67
4	0.79	0.72	0.80	1.00
5	0.83	0.78	0.85	1.00
6	0.87	0.81	0.84	0.75
7	0.90	0.82	0.85	0.97
8	0.92	0.88	0.88	0.98
9	0.95	0.87	0.86	1.00
10	0.91	0.86	0.88	0.93
11	0.94	0.91	0.92	0.91
12	0.90	0.88	0.90	0.97
13	0.95	0.86	0.86	0.97
14	0.89	0.83	0.82	0.95
15	0.82	0.75	0.74	0.90
16	0.83	0.72	0.68	0.94
17	0.77	0.63	0.64	0.83
18	0.79	0.65	0.66	0.83
19	0.85	0.72	0.62	0.77
20	0.79	0.70	0.75	0.90
21	0.78	0.67	0.62	0.70
22	0.79	0.74	0.70	0.85
23	0.79	0.80	0.76	0.69
24	0.79	0.73	0.71	0.70
25	0.76	0.72	0.66	0.70
26	0.82	0.80	0.77	0.51
27	0.69	0.76	0.84	0.56
28	0.65	0.69	0.74	0.52
29	0.71	0.73	0.75	0.51
30	0.68	0.70	0.80	0.53
31	0.73	0.76	0.80	0.61
32	0.67	0.69	0.73	0.60
33	0.69	0.67	0.72	0.55
34	0.72	0.69	0.69	0.46
35	0.72	0.70	0.69	0.71
36	0.72	0.71	0.69	0.65
37	0.77	0.72	0.69	0.67
38	0.74	0.75	0.75	0.68
39	0.77	0.78	0.78	0.74
40	0.77	0.78	0.79	0.75
41	0.74	0.73	0.77	0.68
42	0.79	0.79	0.77	0.79
43	0.81	0.81	0.70	0.76
44	0.78	0.78	0.79	0.74
45	0.76	0.78	0.77	0.74
46	0.80	0.79	0.81	0.94
47	0.78	0.79	0.77	0.77
48	0.72	0.73	0.72	0.57
49	0.69	0.75	0.77	0.61
50	0.64	0.62	0.65	0.91
51	0.61	0.61	0.73	0.69
52	0.59	0.61	0.69	0.60
53	0.59	0.63	0.66	1.00
Grand Total	0.77	0.75	0.76	0.75

TABLE 29

YEAR	(All)	F-NANOPHYTO PIGMENTS (%)

	Data			
WEEK	FNANO_01m	FNANO_05m	FNANO_10m	FNANO_60m
1	0.17	0.21	0.15	0.00
2	0.21	0.23	0.14	0.00
3	0.17	0.18	0.12	0.00
4	0.11	0.19	0.14	0.00
5	0.11	0.17	0.11	0.00
6	0.09	0.14	0.10	0.25
7	0.06	0.12	0.11	0.03
8	0.06	0.09	0.09	0.01
9	0.02	0.10	0.11	0.00
10	0.06	0.09	0.08	0.07
11	0.02	0.04	0.03	0.07
12	0.02	0.03	0.03	0.02
13	0.01	0.05	0.04	0.02
14	0.05	0.07	0.05	0.02
15	0.04	0.08	0.09	0.04
16	0.05	0.08	0.10	0.01
17	0.07	0.08	0.09	0.02
18	0.05	0.08	0.10	0.04
19	0.05	0.11	0.13	0.10
20	0.07	0.12	0.11	0.02
21	0.09	0.19	0.23	0.11
22	0.08	0.12	0.21	0.10
23	0.09	0.08	0.14	0.23
24	0.07	0.11	0.16	0.24
25	0.09	0.14	0.19	0.26
26	0.08	0.10	0.17	0.49
27	0.15	0.13	0.10	0.43
28	0.14	0.14	0.16	0.37
29	0.11	0.13	0.16	0.38
30	0.10	0.14	0.13	0.41
31	0.10	0.13	0.14	0.34
32	0.14	0.16	0.16	0.40
33	0.14	0.16	0.15	0.44
34	0.14	0.17	0.19	0.54
35	0.13	0.16	0.19	0.25
36	0.14	0.15	0.16	0.32
37	0.11	0.14	0.18	0.12
38	0.12	0.12	0.13	0.23
39	0.12	0.12	0.13	0.26
40	0.12	0.12	0.12	0.25
41	0.16	0.16	0.15	0.32
42	0.12	0.16	0.14	0.20
43	0.09	0.11	0.17	0.21
44	0.11	0.11	0.12	0.26
45	0.13	0.13	0.13	0.26
46	0.11	0.14	0.13	0.05
47	0.10	0.13	0.16	0.23
48	0.17	0.16	0.19	0.30
49	0.17	0.15	0.14	0.39
50	0.22	0.23	0.24	0.09
51	0.20	0.24	0.14	0.31
52	0.28	0.27	0.19	0.20
53	0.24	0.22	0.15	0.00
Grand Total	0.11	0.13	0.13	0.20

TABLE 30

YEAR	(All)	F-PICOPHYTO PIGMENTS (%)

	Data			
WEEK	FPICO_01m	FPICO_05m	FPICO_10m	FPICO_60m
1	0.13	0.10	0.13	0.25
2	0.15	0.10	0.11	0.06
3	0.12	0.12	0.16	0.33
4	0.10	0.09	0.06	0.00
5	0.06	0.05	0.05	0.00
6	0.04	0.05	0.06	0.00
7	0.04	0.05	0.04	0.00
8	0.02	0.03	0.03	0.02
9	0.03	0.03	0.03	0.00
10	0.04	0.05	0.04	0.00
11	0.04	0.06	0.04	0.02
12	0.08	0.09	0.07	0.01
13	0.04	0.10	0.10	0.01
14	0.06	0.10	0.12	0.02
15	0.14	0.18	0.17	0.07
16	0.12	0.20	0.22	0.05
17	0.16	0.28	0.27	0.15
18	0.16	0.27	0.24	0.13
19	0.10	0.17	0.24	0.13
20	0.13	0.18	0.13	0.08
21	0.13	0.14	0.15	0.19
22	0.13	0.14	0.09	0.04
23	0.12	0.12	0.10	0.08
24	0.15	0.16	0.13	0.07
25	0.15	0.14	0.15	0.04
26	0.11	0.10	0.06	0.00
27	0.16	0.11	0.06	0.01
28	0.20	0.17	0.10	0.10
29	0.18	0.14	0.09	0.11
30	0.22	0.16	0.08	0.06
31	0.17	0.11	0.06	0.04
32	0.19	0.15	0.11	0.01
33	0.18	0.17	0.12	0.02
34	0.14	0.14	0.12	0.00
35	0.15	0.14	0.12	0.04
36	0.15	0.14	0.15	0.03
37	0.13	0.14	0.14	0.21
38	0.14	0.12	0.11	0.09
39	0.12	0.10	0.09	0.00
40	0.11	0.10	0.09	0.01
41	0.11	0.10	0.09	0.00
42	0.09	0.05	0.09	0.02
43	0.10	0.08	0.14	0.04
44	0.12	0.11	0.09	0.00
45	0.10	0.09	0.09	0.00
46	0.09	0.07	0.06	0.00
47	0.12	0.08	0.06	0.00
48	0.12	0.11	0.09	0.13
49	0.14	0.10	0.09	0.00
50	0.14	0.15	0.12	0.00
51	0.19	0.15	0.13	0.00
52	0.13	0.12	0.11	0.20
53	0.17	0.15	0.18	0.00
Grand Total	0.12	0.12	0.11	0.05

TABLE 31

YEAR	(All)	Phytoplankton absorption coefficients

	Data			
WEEK	a443ph_1m	a555ph_1m	a676ph_1m	a555ph/a443ph
1	0.032	0.010	0.019	0.268
2	0.029	0.010	0.021	0.275
3	0.027	0.009	0.017	0.263
4	0.031	0.009	0.014	0.267
5	0.034	0.011	0.020	0.261
6	0.030	0.011	0.020	0.306
7	0.028	0.009	0.021	0.260
8	0.046	0.015	0.029	0.326
9	0.054	0.015	0.039	0.252
10	0.096	0.026	0.064	0.256
11	0.133	0.036	0.108	0.261
12	0.114	0.027	0.090	0.213
13	0.154	0.035	0.118	0.197
14	0.255	0.034	0.138	0.173
15	0.213	0.037	0.128	0.167
16	0.119	0.019	0.068	0.151
17	0.129	0.021	0.080	0.151
18	0.108	0.017	0.069	0.143
19	0.106	0.019	0.063	0.162
20	0.109	0.021	0.076	0.160
21	0.104	0.022	0.082	0.170
22	0.121	0.028	0.105	0.195
23	0.186	0.042	0.134	0.197
24	0.140	0.022	0.077	0.146
25	0.173	0.036	0.120	0.175
26	0.254	0.057	0.153	0.189
27	0.242	0.047	0.143	0.178
28	0.161	0.028	0.099	0.151
29	0.180	0.031	0.127	0.145
30	0.210	0.033	0.128	0.141
31	0.175	0.028	0.099	0.151
32	0.191	0.034	0.123	0.158
33	0.183	0.037	0.143	0.163
34	0.189	0.034	0.126	0.154
35	0.235	0.049	0.168	0.170
36	0.272	0.057	0.174	0.186
37	0.236	0.046	0.144	0.175
38	0.221	0.045	0.140	0.185
39	0.224	0.055	0.173	0.210
40	0.234	0.048	0.130	0.199
41	0.204	0.052	0.121	0.247
42	0.143	0.038	0.079	0.276
43	0.136	0.035	0.084	0.230
44	0.114	0.029	0.066	0.246
45	0.180	0.049	0.108	0.264
46	0.130	0.038	0.111	0.265
47	0.098	0.033	0.072	0.302
48	0.084	0.024	0.049	0.287
49	0.057	0.021	0.039	0.333
50	0.050	0.016	0.033	0.286
51	0.042	0.015	0.026	0.292
52	0.026	0.010	0.020	0.296
53	0.018	0.004	0.006	0.208
Grand Total	0.139	0.030	0.091	0.215

Figure 1

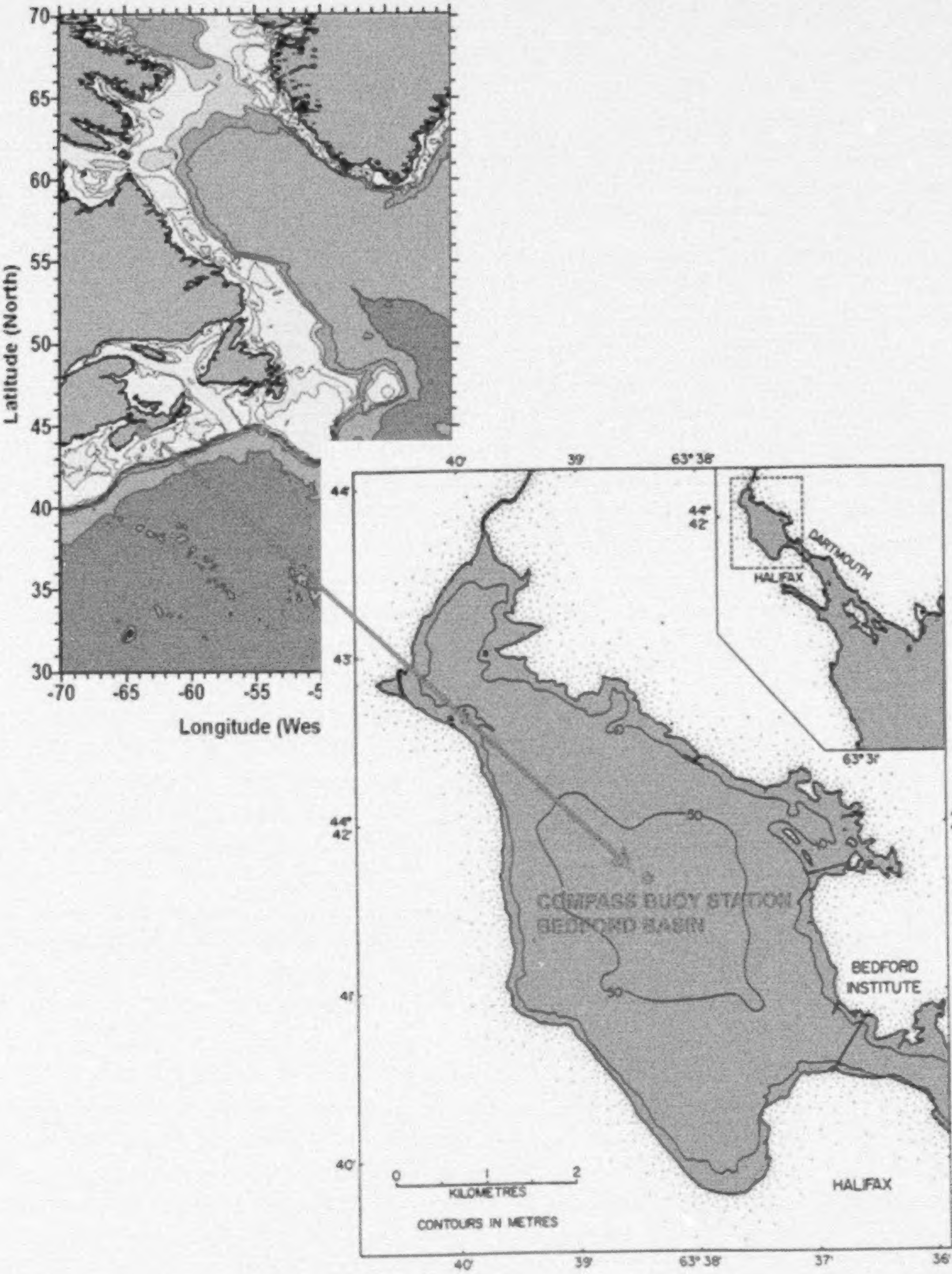
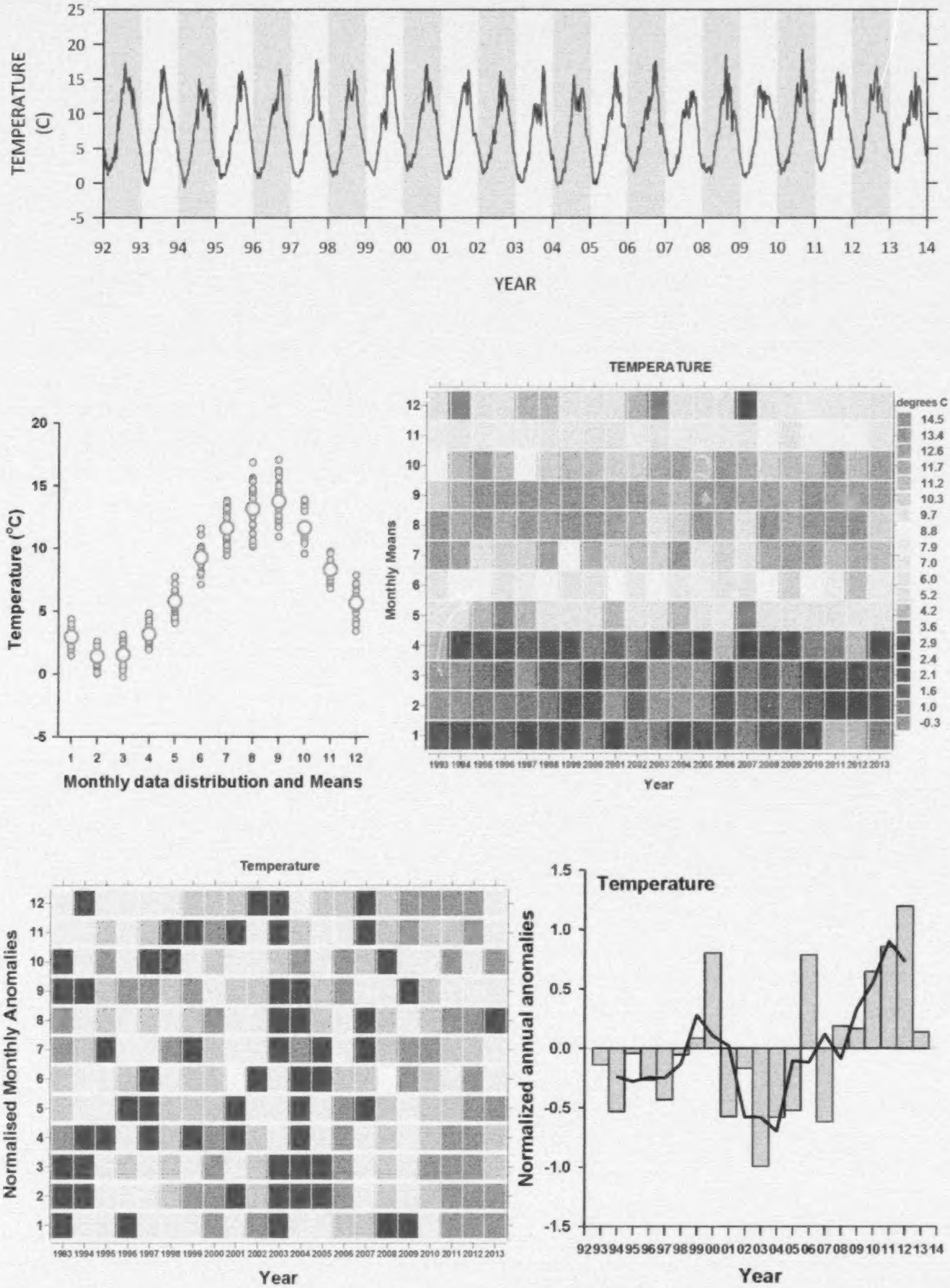

70
65
60
55
50
45
40
35
30
-70
-65
-60
-55
Latitude (North)
Longitude (Wes
40'
39'
63° 38'
44°
42'
DARTMOUTH
HALIFAX
63° 31'
43'
50
COMPASS BUOY STATION
BEDFORD BASIN
BEDFORD INSTITUTE
41'
40'
0
1
2
KILOMETRES
CONTOURS IN METRES
HALIFAX
37'
36'

Figure 2



TEMPERATURE (C)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Temperature (°C)
Monthly data distribution and Means
TEMPERATURE
Monthly Means
degrees C
14.5
13.4
12.6
11.7
11.2
10.3
9.7
8.8
7.9
7.0
6.0
5.2
4.2
3.6
2.9
2.4
2.1
1.6
1.0
-0.3
Year
Temperature
Normalised Monthly Anomalies
Year
Temperature
Normalized annual anomalies
Year

Figure 3

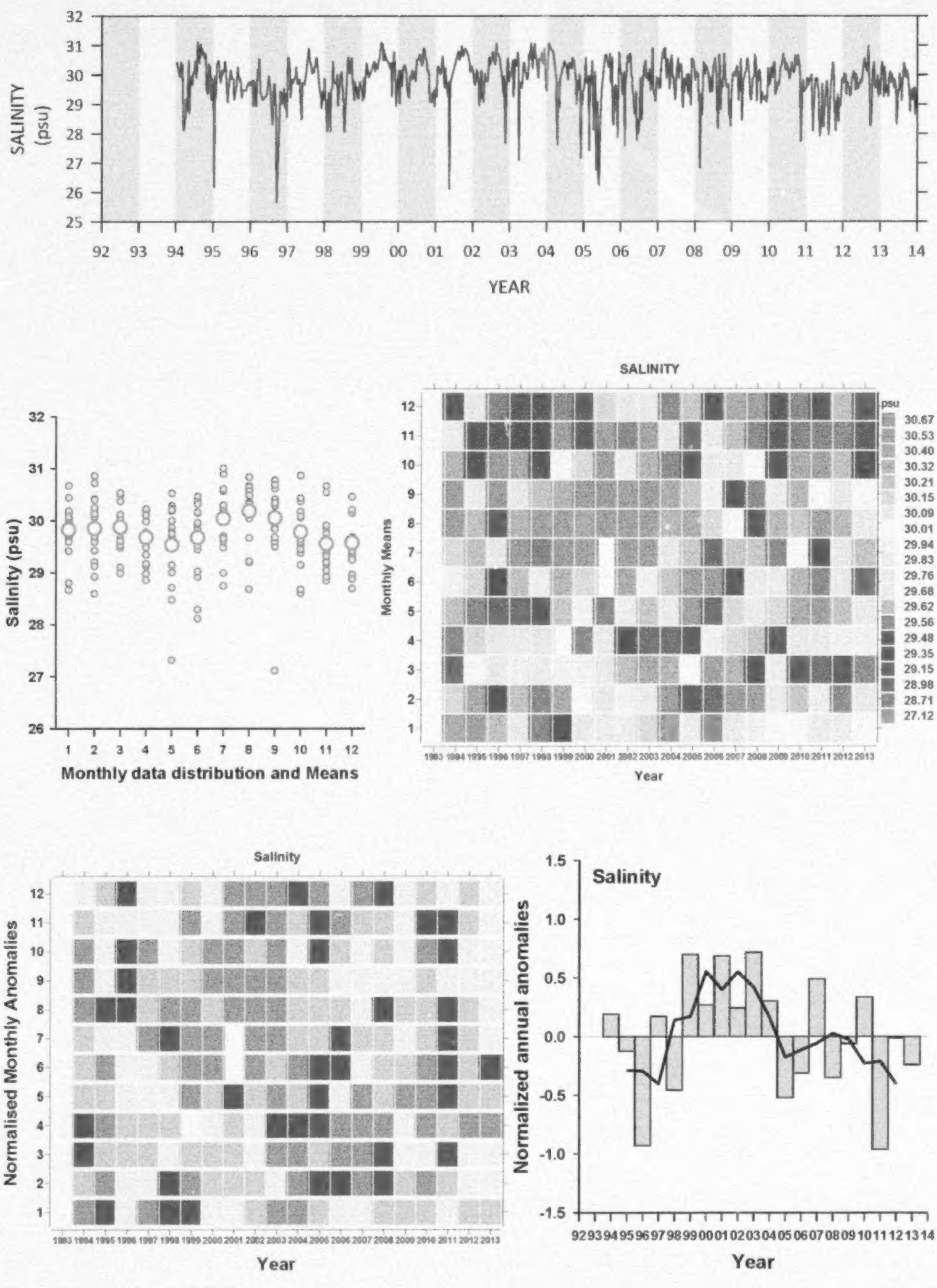

SALINITY
(psu)
YEAR
SALINITY
Salinity (psu)
Monthly data distribution and Means
Monthly Means
Year
psu
Salinity
Normalised Monthly Anomalies
Year
Salinity
Normalized annual anomalies
Year

Figure 4

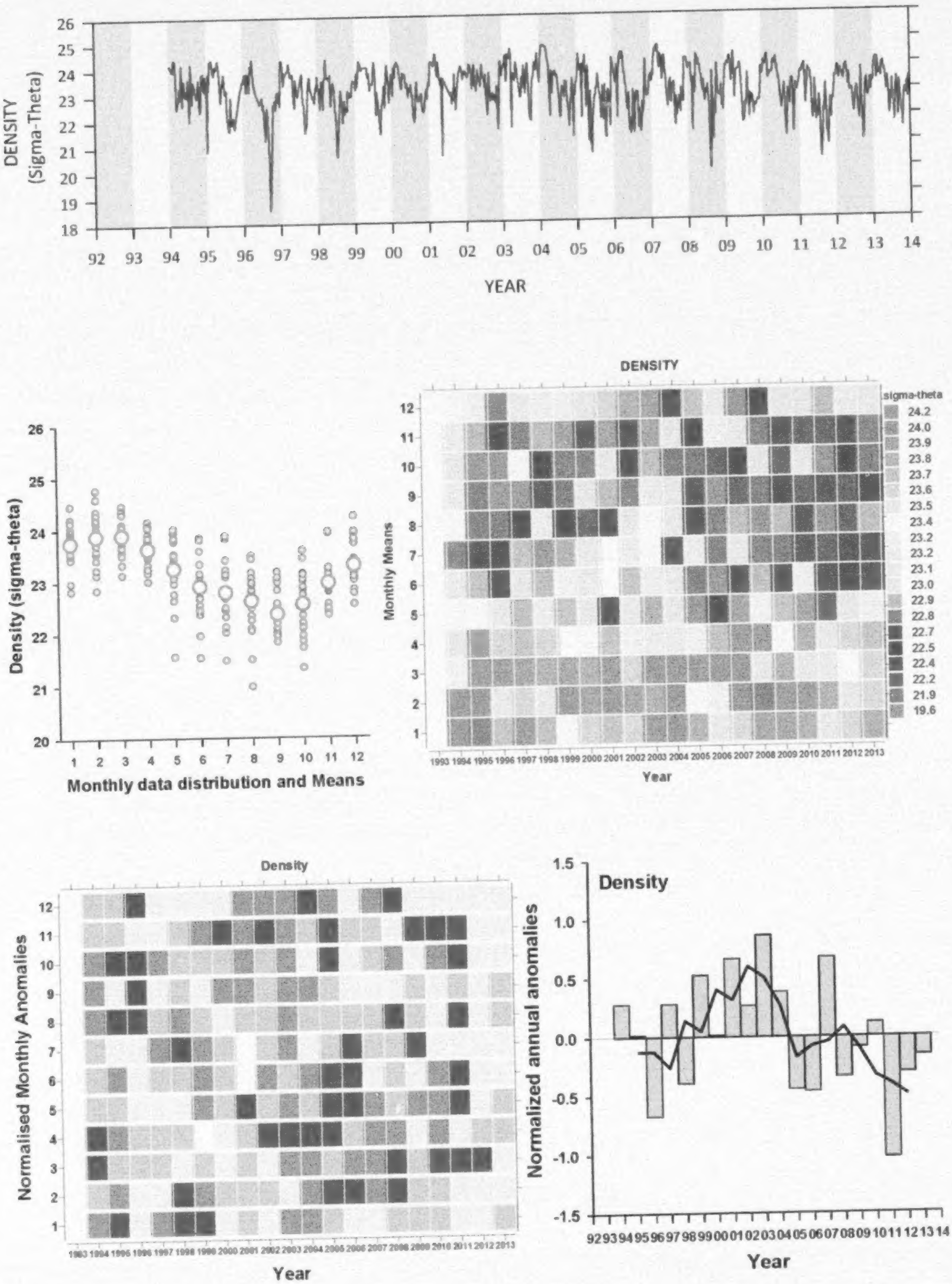

DENSITY
(Sigma-Theta)
YEAR
Density (sigma-theta)
Monthly data distribution and Means
DENSITY
Monthly Means
sigma-theta
Year
Density
Normalised Monthly Anomalies
Year
Density
Normalized annual anomalies
Year

Figure 5

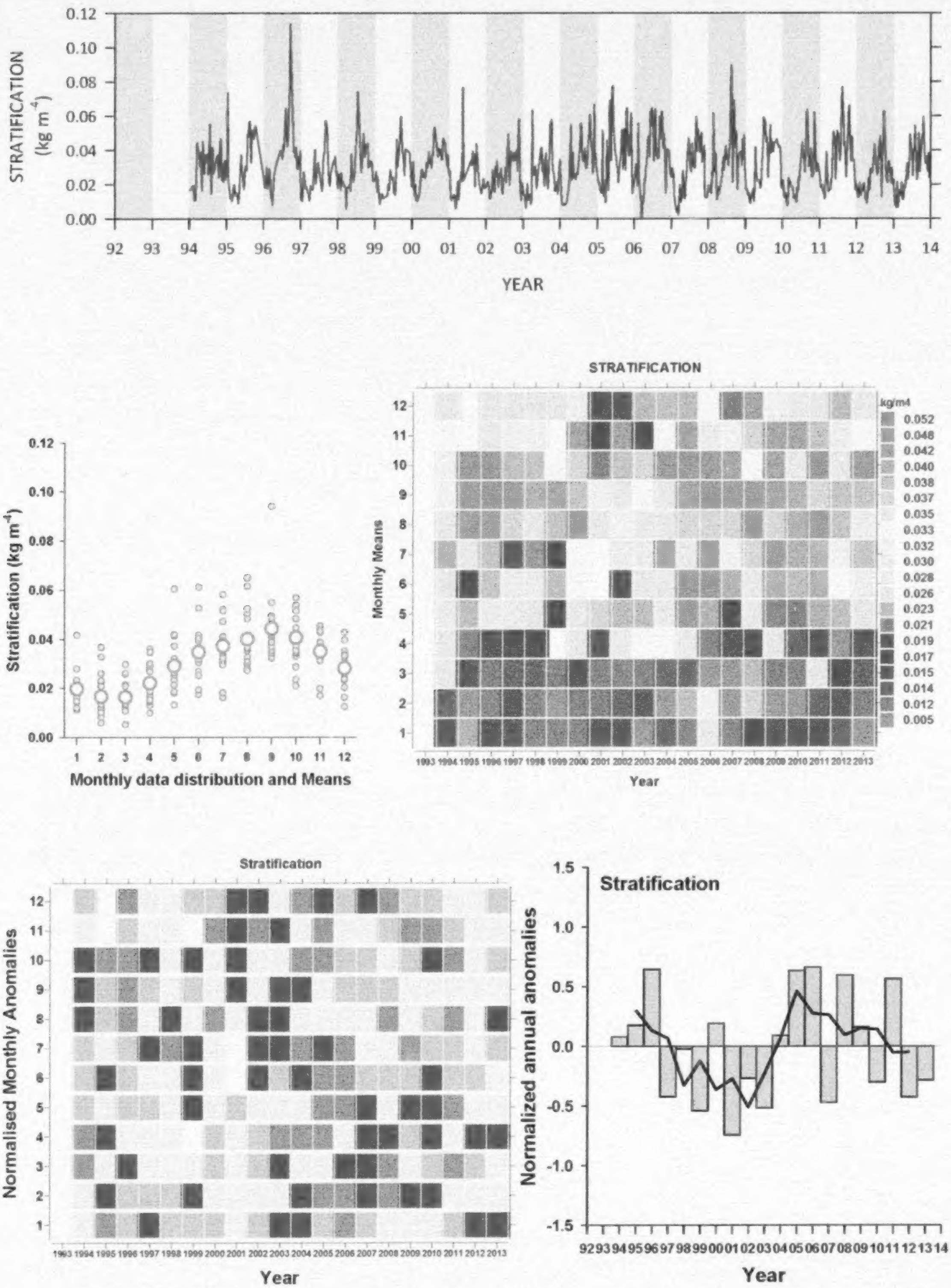
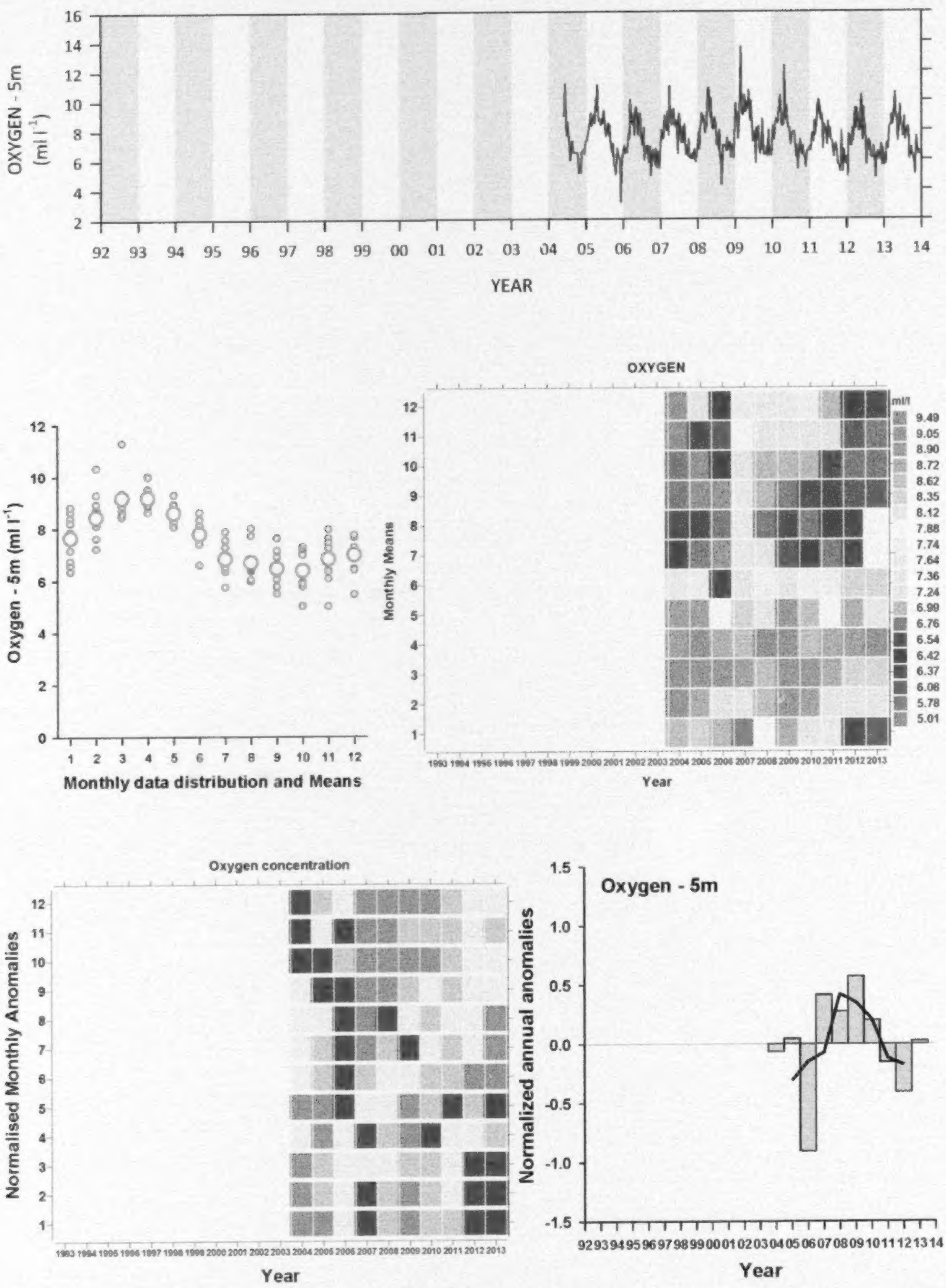
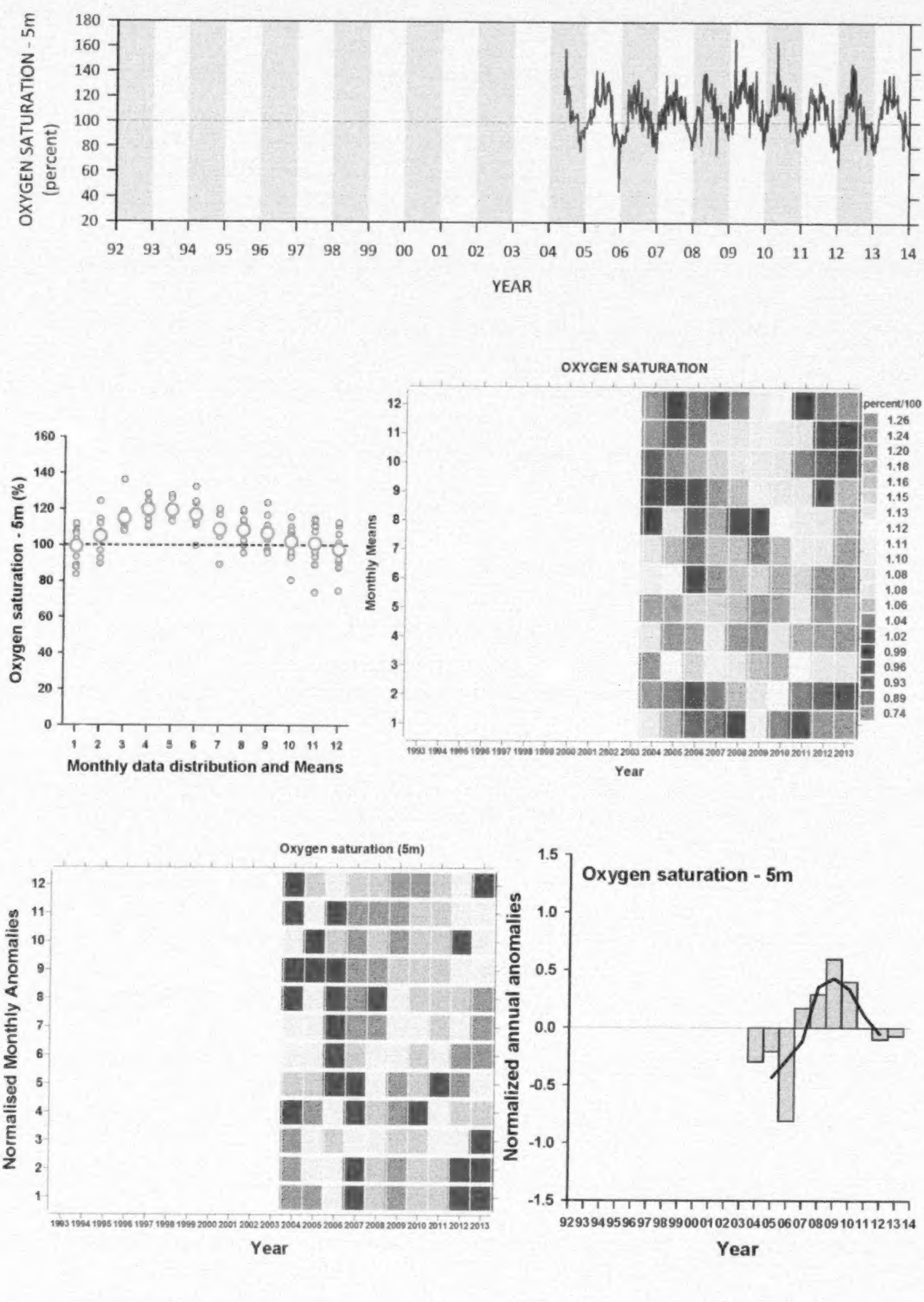

STRATIFICATION (kg m^{-4})
YEAR
Stratification (kg m^{-4})
Monthly data distribution and Means
STRATIFICATION
Monthly Means
Year
kg/m4
0.052
0.048
0.042
0.040
0.038
0.037
0.035
0.033
0.032
0.030
0.028
0.026
0.023
0.021
0.019
0.017
0.015
0.014
0.012
0.005
Stratification
Normalised Monthly Anomalies
Year
Stratification
Normalized annual anomalies
Year

Figure 6



OXYGEN - 5m
(ml l^{-1})
16
14
12
10
8
6
4
2
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
Oxygen - 5m (ml l^{-1})
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12
Monthly data distribution and Means
OXYGEN
Monthly Means
ml/l
9.49
9.05
8.90
8.72
8.62
8.35
8.12
7.88
7.74
7.64
7.36
7.24
6.99
6.76
6.54
6.42
6.37
6.08
5.78
5.01
Year
Oxygen concentration
Normalised Monthly Anomalies
Year
Oxygen - 5m
Normalized annual anomalies
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 7



OXYGEN SATURATION - 5m (percent)
180
160
140
120
100
80
60
40
20
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
Oxygen saturation - 5m (%)
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12
Monthly data distribution and Means
OXYGEN SATURATION
Monthly Means
percent/100
1.26
1.24
1.20
1.18
1.16
1.15
1.13
1.12
1.11
1.10
1.08
1.08
1.06
1.04
1.02
0.99
0.96
0.93
0.89
0.74
Year
Oxygen saturation (5m)
Normalised Monthly Anomalies
Year
Oxygen saturation - 5m
Normalized annual anomalies
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 8

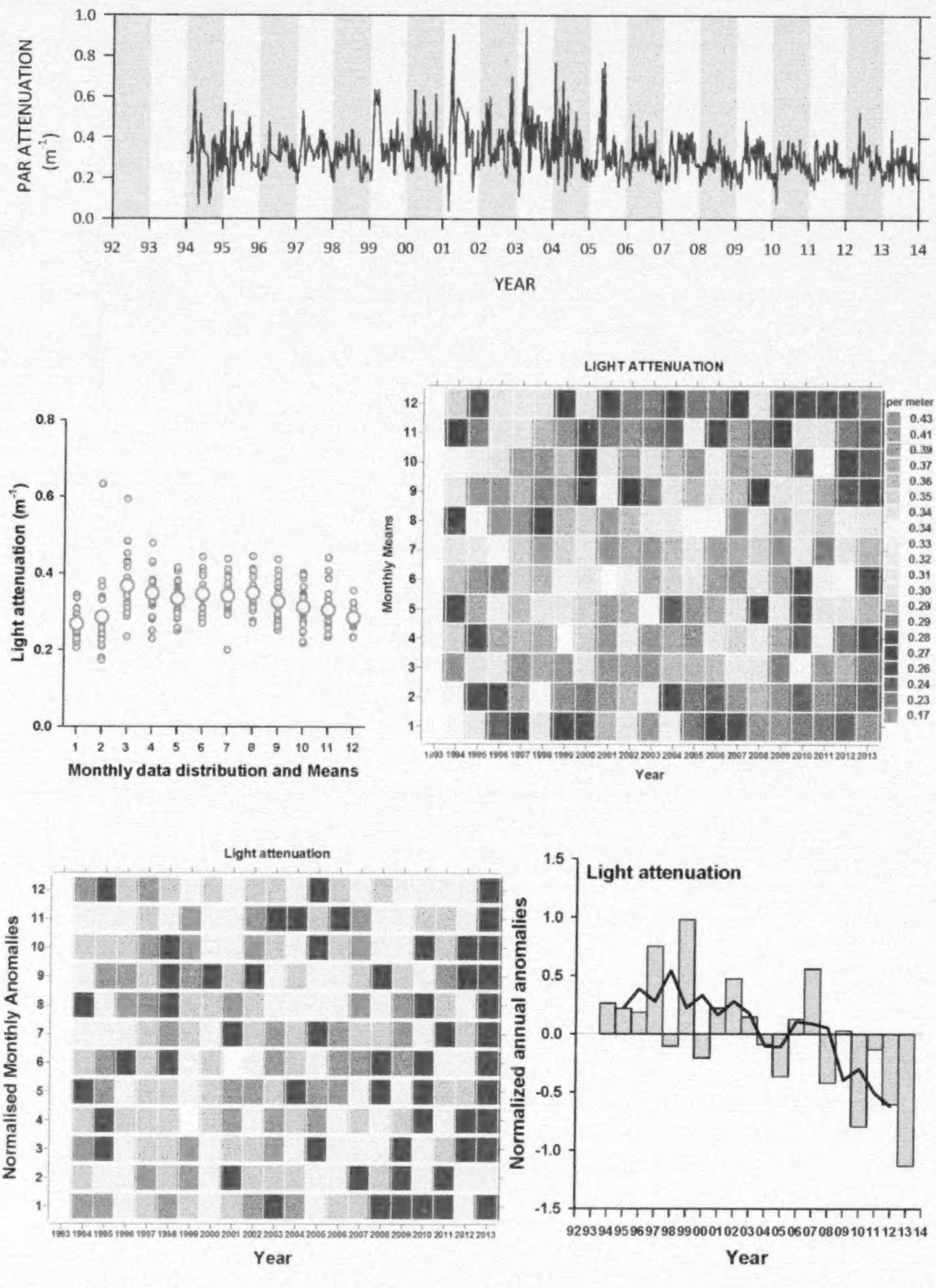

PAR ATTENUATION (m^{-1})
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Light attenuation (m^{-1})
Monthly data distribution and Means
LIGHT ATTENUATION
Monthly Means
per meter
0.43
0.41
0.39
0.37
0.36
0.35
0.34
0.34
0.33
0.32
0.31
0.30
0.29
0.29
0.28
0.27
0.26
0.24
0.23
0.17
Year
Light attenuation
Normalised Monthly Anomalies
Year
Light attenuation
Normalized annual anomalies
Year

Figure 9

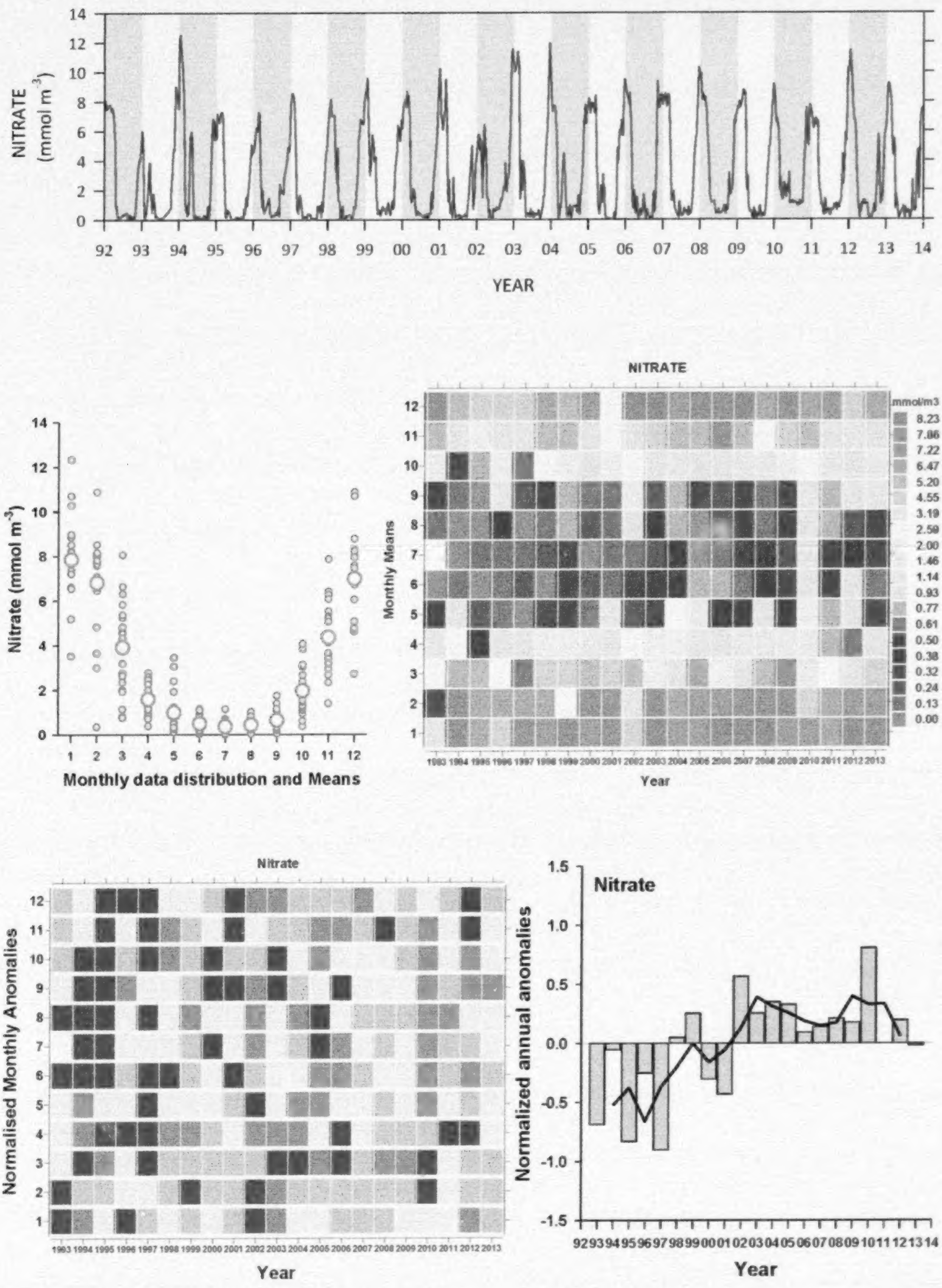

NITRATE (mmol m-3)
YEAR
Nitrate (mmol m-3)
Monthly data distribution and Means
NITRATE
Monthly Means
mmol/m3
8.23
7.86
7.22
6.47
5.20
4.55
3.19
2.59
2.00
1.46
1.14
0.93
0.77
0.61
0.50
0.38
0.32
0.24
0.13
0.00
Year
Nitrate
Normalised Monthly Anomalies
Year
Nitrate
Normalized annual anomalies
Year

Figure 10

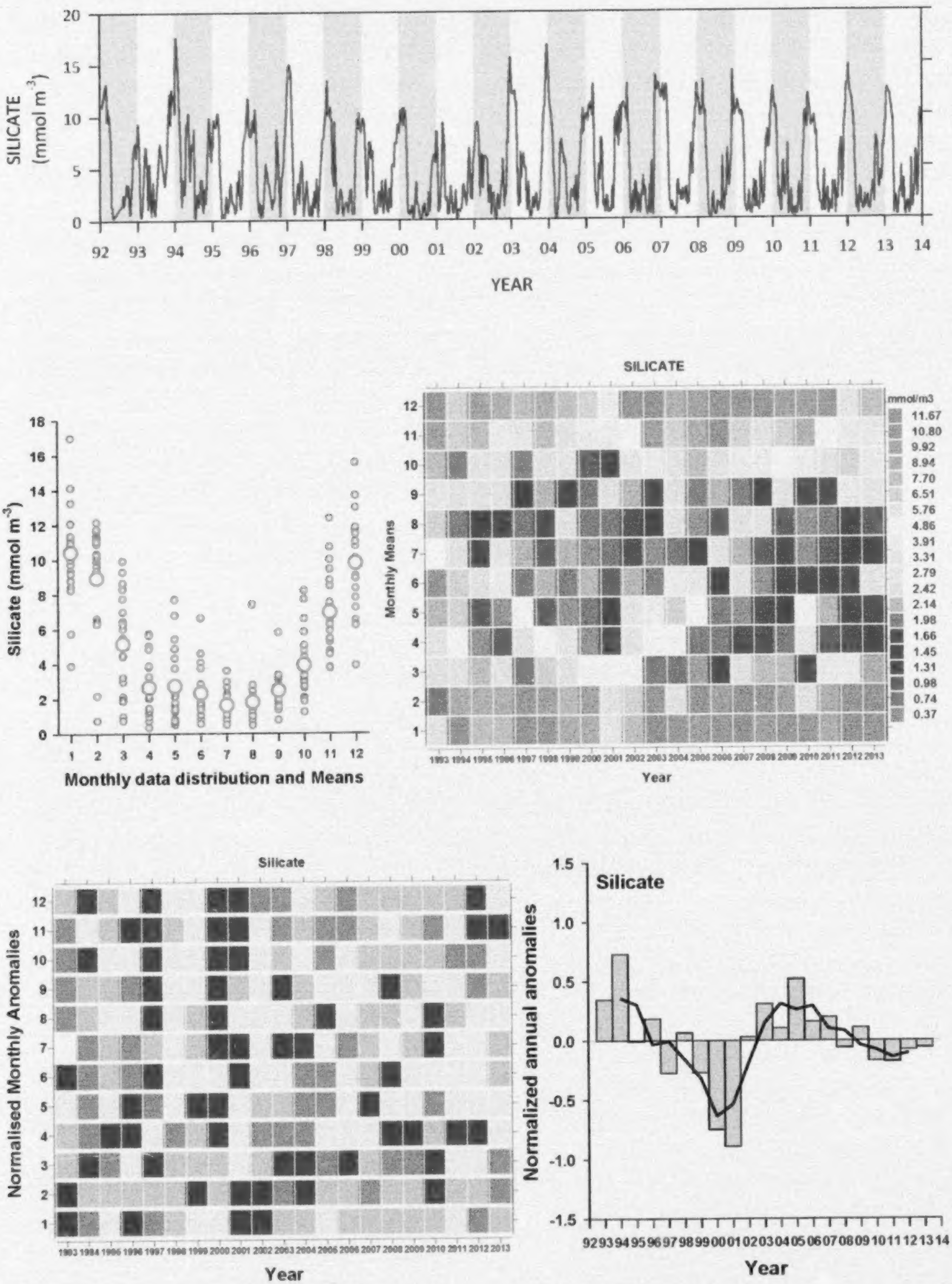

SILICATE (mmol m-3)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Silicate (mmol m-3)
Monthly data distribution and Means
SILICATE
mmol/m3
11.67
10.80
9.92
8.94
7.70
6.51
5.76
4.86
3.91
3.31
2.79
2.42
2.14
1.98
1.66
1.45
1.31
0.98
0.74
0.37
Monthly Means
Year
Silicate
Normalised Monthly Anomalies
Year
Silicate
Normalized annual anomalies
Year

Figure 11

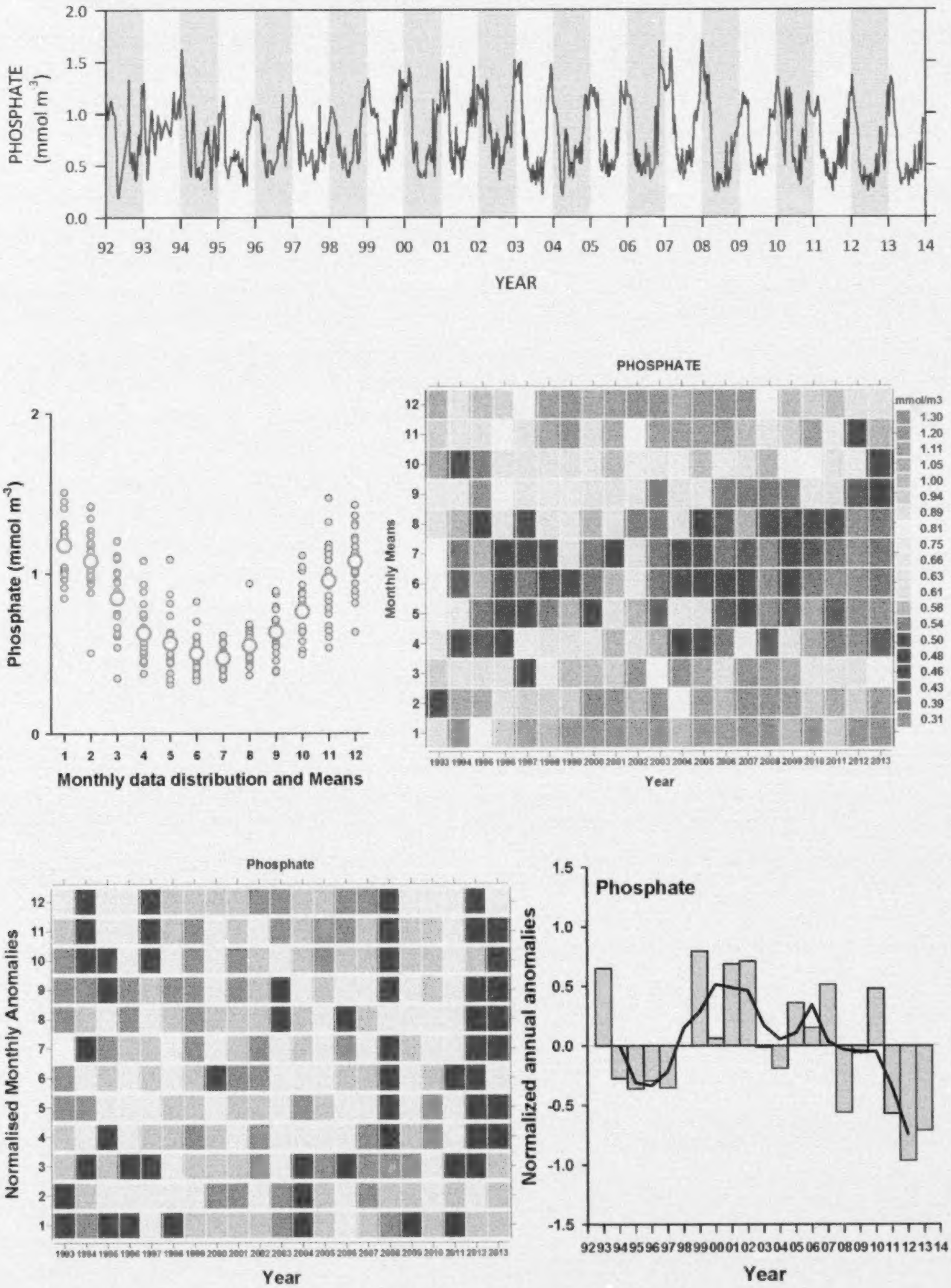

PHOSPHATE (mmol m^{-3})
YEAR
Phosphate (mmol m^{-3})
Monthly data distribution and Means
PHOSPHATE
Monthly Means
mmol/m3
1.30
1.20
1.11
1.05
1.00
0.94
0.89
0.81
0.75
0.66
0.63
0.61
0.58
0.54
0.50
0.48
0.46
0.43
0.39
0.31
Year
Phosphate
Normalised Monthly Anomalies
Year
Phosphate
Normalized annual anomalies
Year

Figure 12

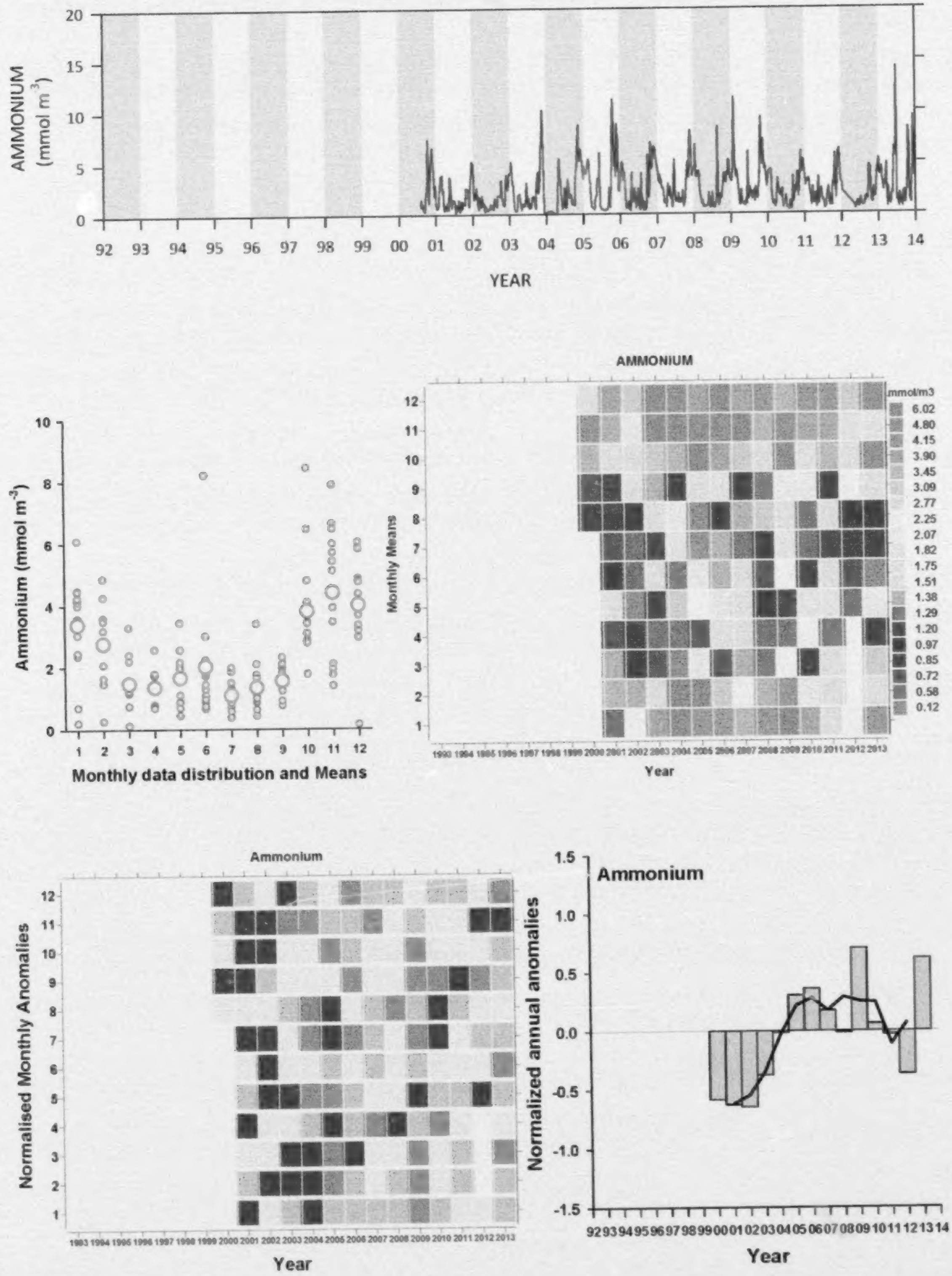
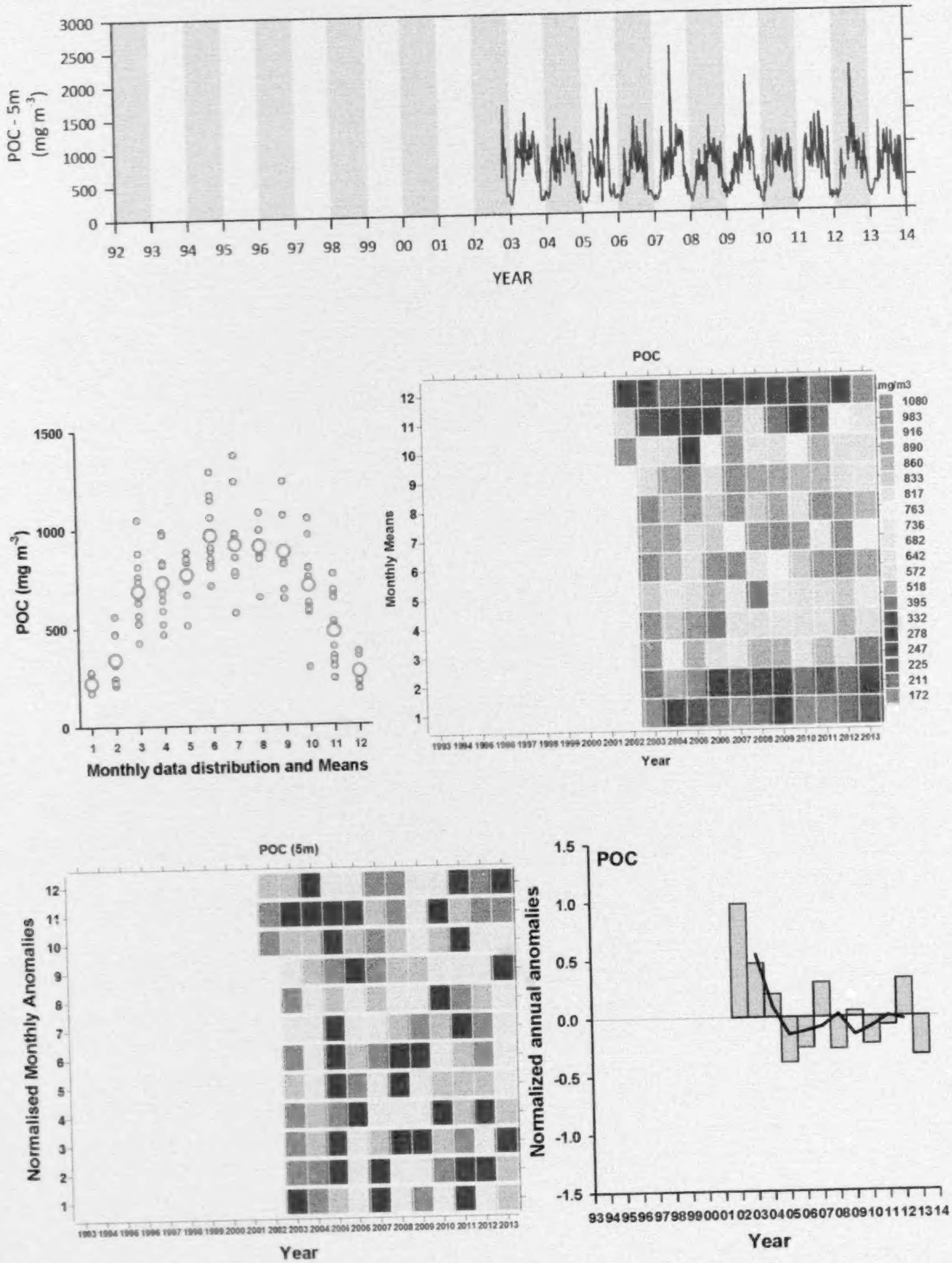

AMMONIUM (mmol m^{-3})
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Ammonium (mmol m^{-3})
Monthly data distribution and Means
AMMONIUM
Monthly Means
Year
mmol/m3
6.02
4.80
4.15
3.90
3.45
3.09
2.77
2.25
2.07
1.82
1.75
1.51
1.38
1.29
1.20
0.97
0.85
0.72
0.58
0.12
Ammonium
Normalised Monthly Anomalies
Year
Ammonium
Normalized annual anomalies
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 13



POC - 5m (mg m^{-3})
YEAR
POC (mg m^{-3})
Monthly data distribution and Means
POC
Monthly Means
Year
mg/m3
1080
983
916
890
860
833
817
763
736
682
642
572
518
395
332
278
247
225
211
172
POC (5m)
Normalised Monthly Anomalies
Year
POC
Normalized annual anomalies
Year

Figure 14

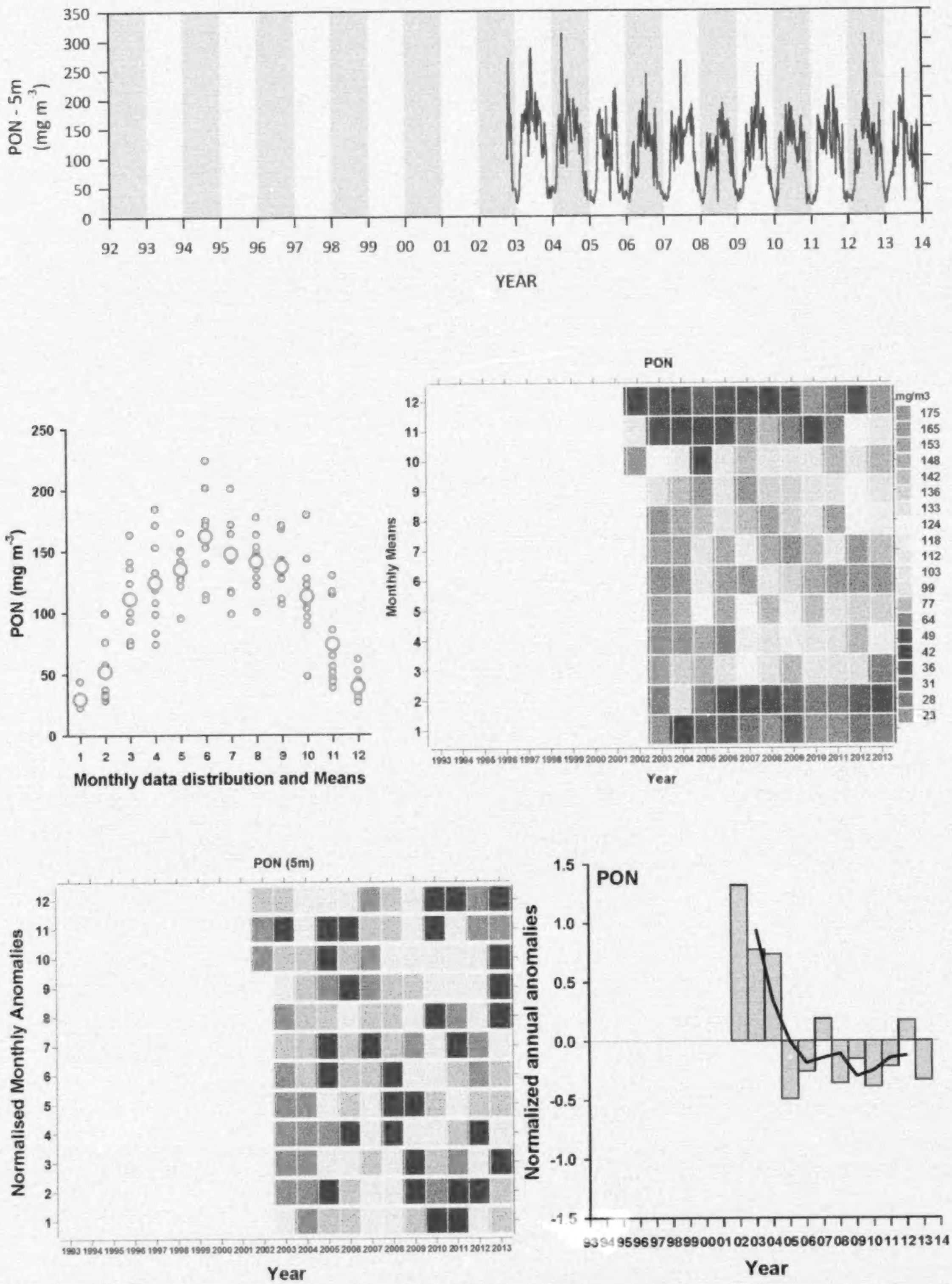

PON - 5m
(mg m^{-3})
YEAR
PON (mg m^{-3})
Monthly data distribution and Means
PON
Monthly Means
mg/m3
Year
PON (5m)
Normalised Monthly Anomalies
Year
PON
Normalized annual anomalies
Year

Figure 15

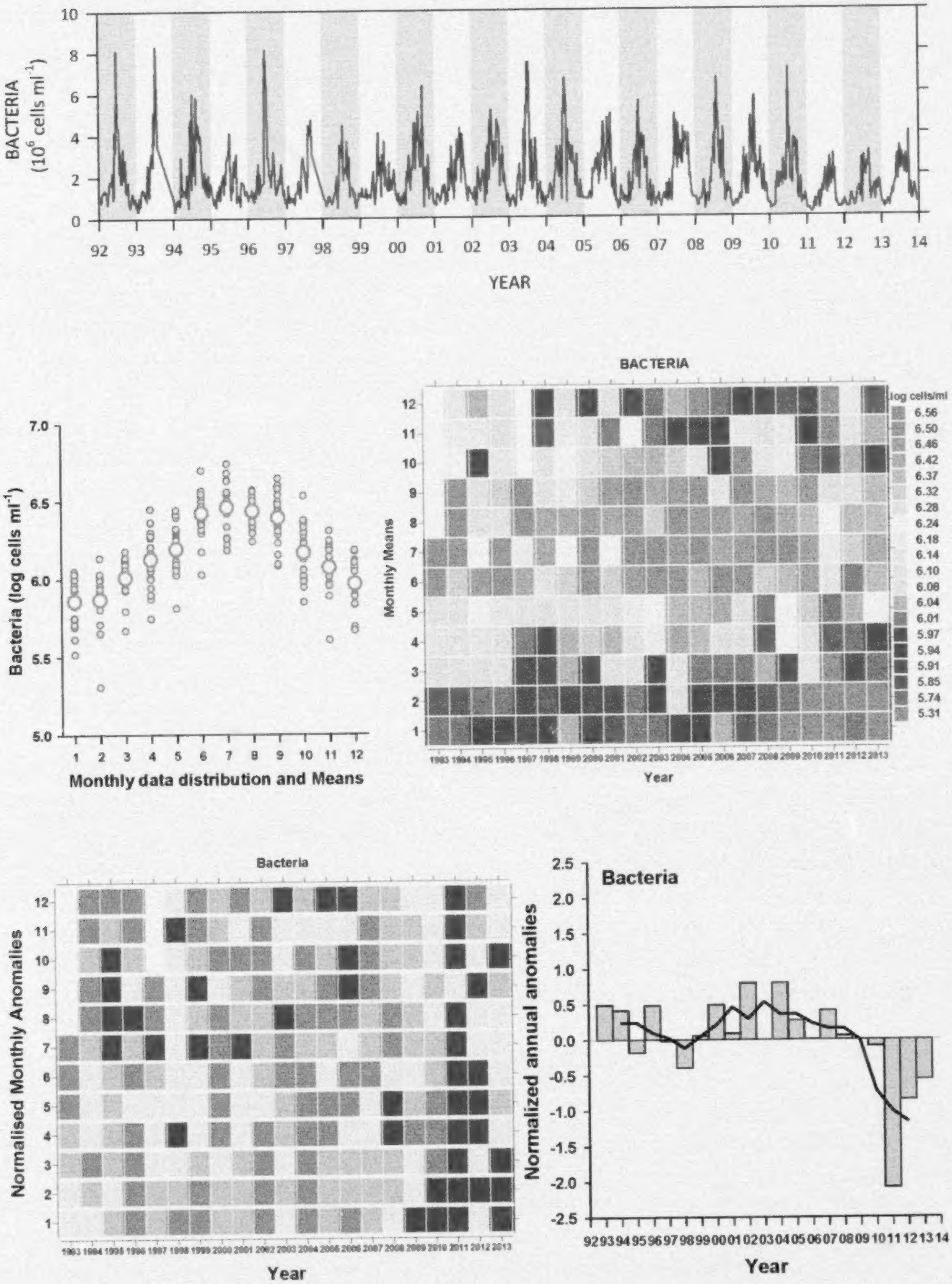

BACTERIA
(10^6 cells ml^{-1})
YEAR
Bacteria (log cells ml^{-1})
Monthly data distribution and Means
BACTERIA
Monthly Means
log cells/ml
Year
Bacteria
Normalised Monthly Anomalies
Year
Bacteria
Normalized annual anomalies
Year

Figure 16

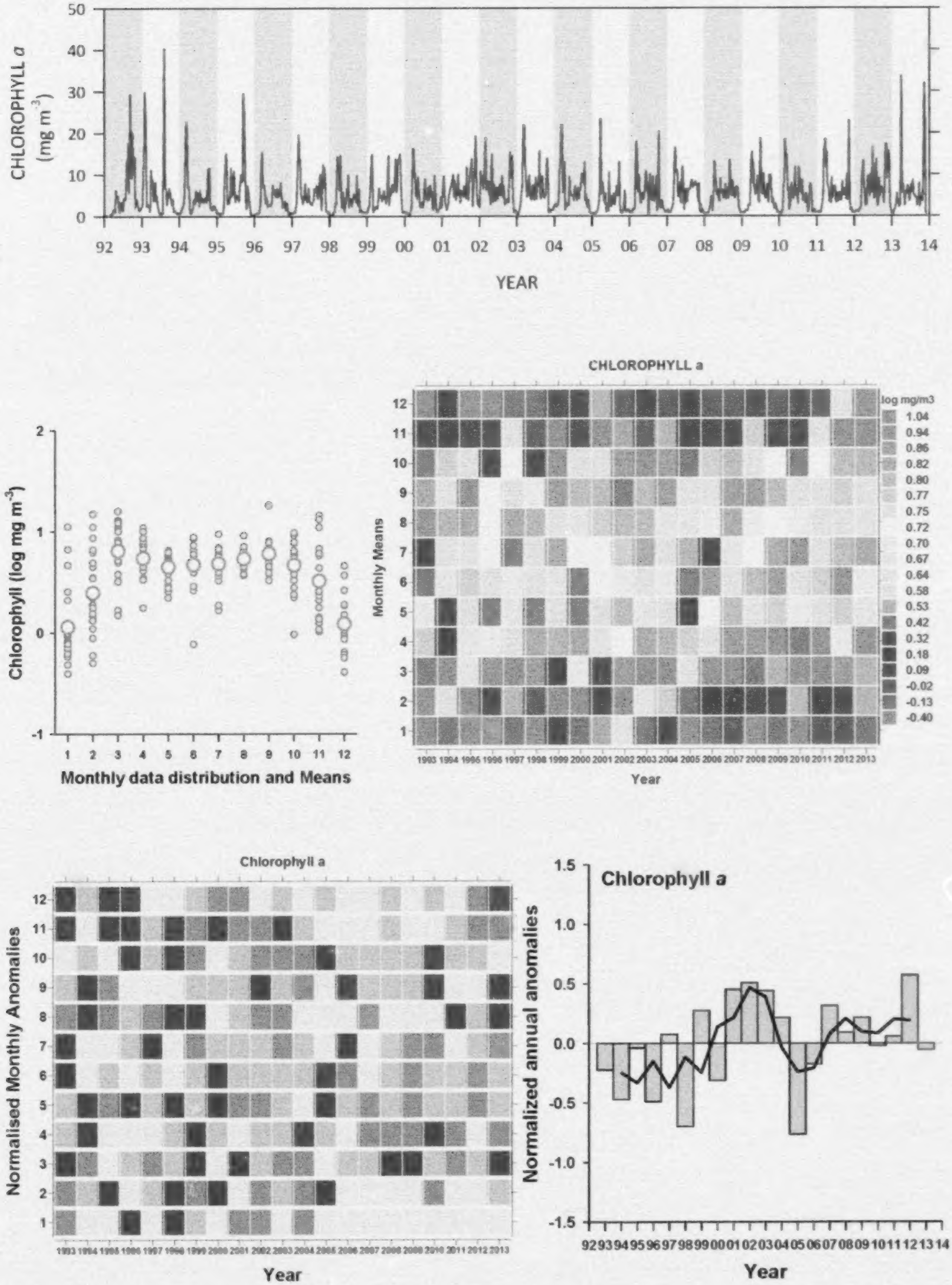

CHLOROPHYLL a (mg m-3)
YEAR
Chlorophyll (log mg m-3)
Monthly data distribution and Means
CHLOROPHYLL a
Monthly Means
log mg/m3
Year
Chlorophyll a
Normalised Monthly Anomalies
Year
Chlorophyll a
Normalized annual anomalies
Year

Figure 17

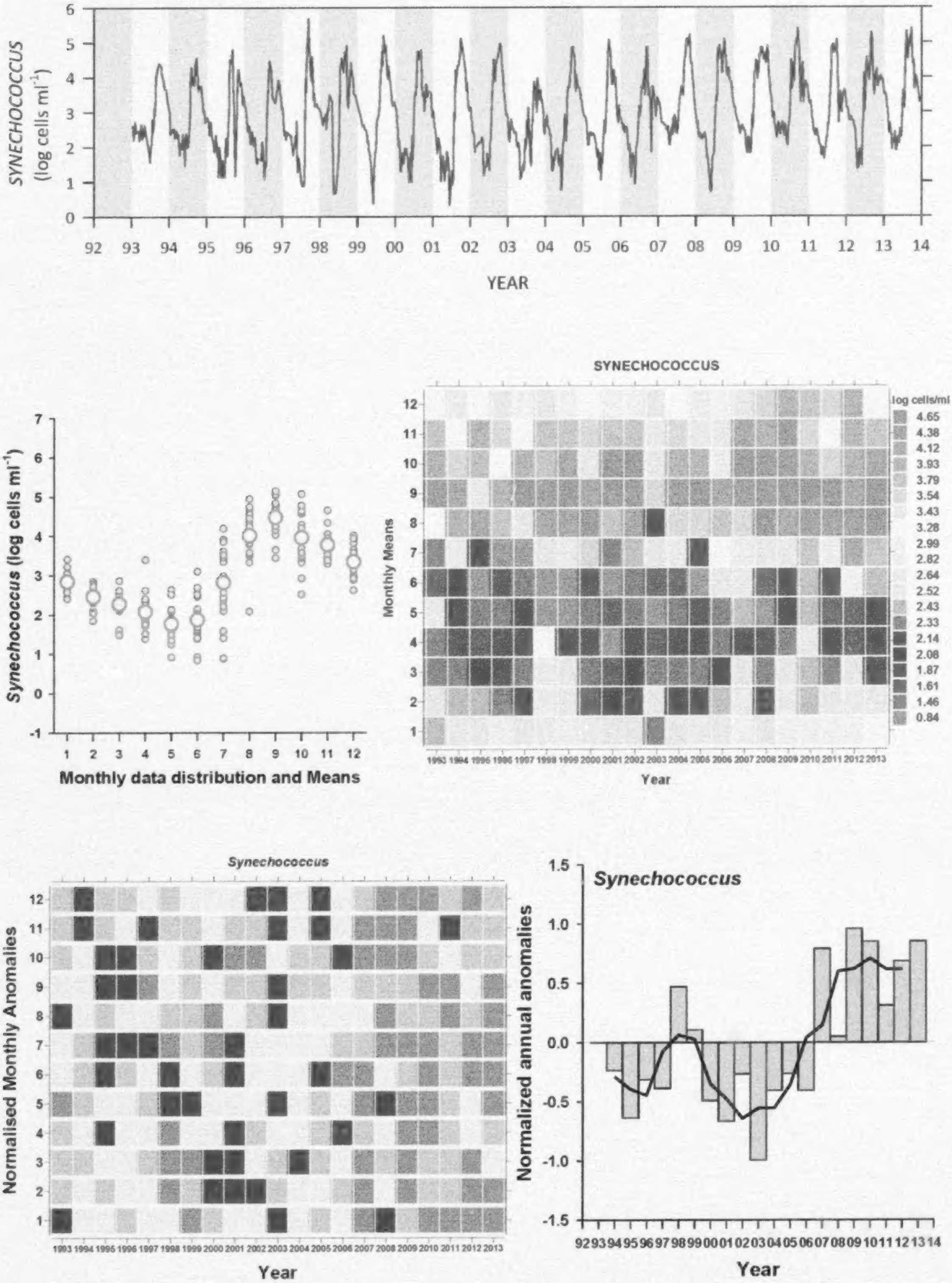

SYNECHOCOCCUS (log cells ml^{-1})
YEAR
Synechococcus (log cells ml^{-1})
Monthly data distribution and Means
SYNECHOCOCCUS
Monthly Means
log cells/ml
4.65
4.38
4.12
3.93
3.79
3.54
3.43
3.28
2.99
2.82
2.64
2.52
2.43
2.33
2.14
2.08
1.87
1.61
1.46
0.84
Year
Synechococcus
Normalised Monthly Anomalies
Year
Synechococcus
Normalized annual anomalies
Year

Figure 18

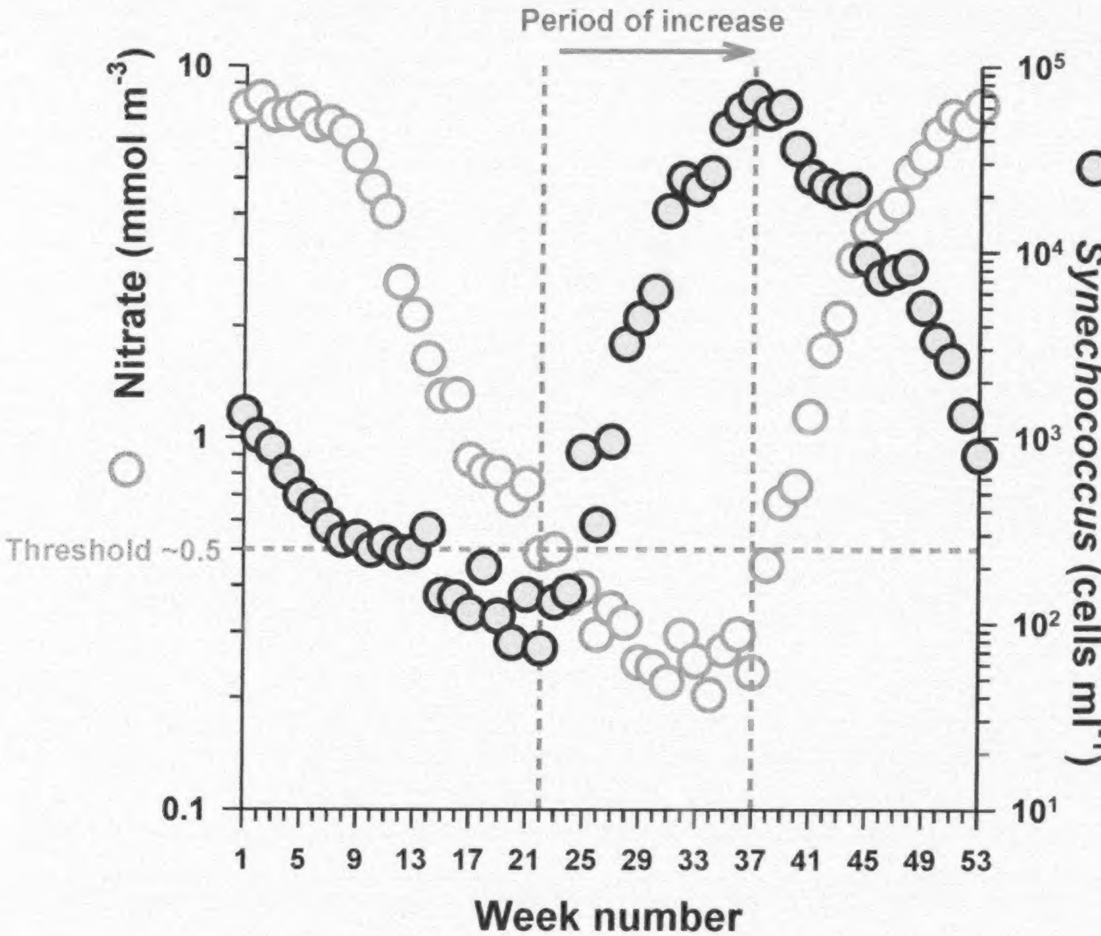

Period of increase
Nitrate (mmol m-3)
10
1
Threshold ~0.5
0.1
1 5 9 13 17 21 25 29 33 37 41 45 49 53
Week number
10⁵
10⁴
10³
10²
10¹
Synechococcus (cells ml-1)

Figure 19

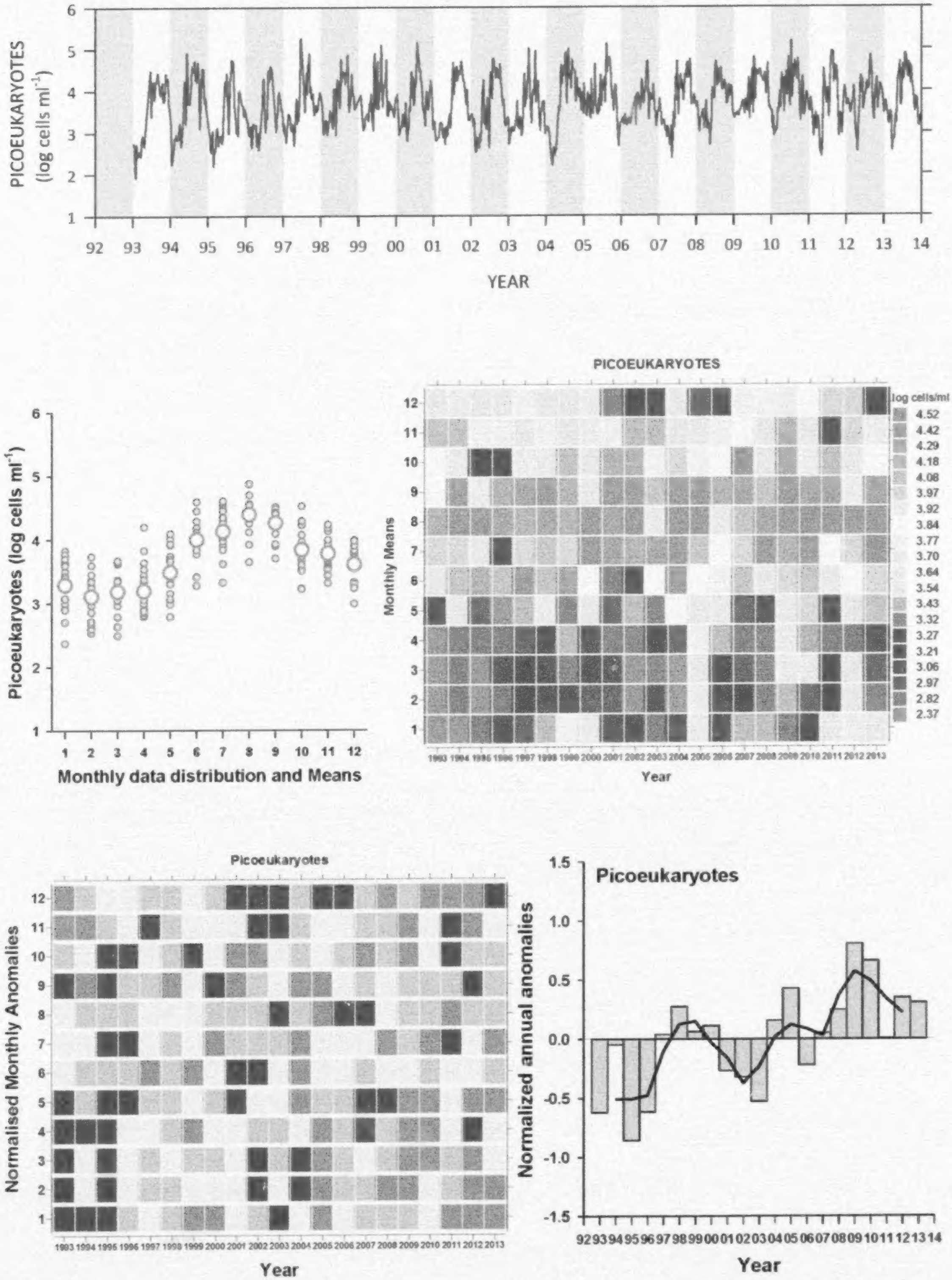

PICOEUKARYOTES
(log cells ml-1)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Picoeukaryotes (log cells ml-1)
Monthly data distribution and Means
PICOEUKARYOTES
Monthly Means
log cells/ml
4.52
4.42
4.29
4.18
4.08
3.97
3.92
3.84
3.77
3.70
3.64
3.54
3.43
3.32
3.27
3.21
3.06
2.97
2.82
2.37
Year
Picoeukaryotes
Normalised Monthly Anomalies
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year
Picoeukaryotes
Normalized annual anomalies
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 20

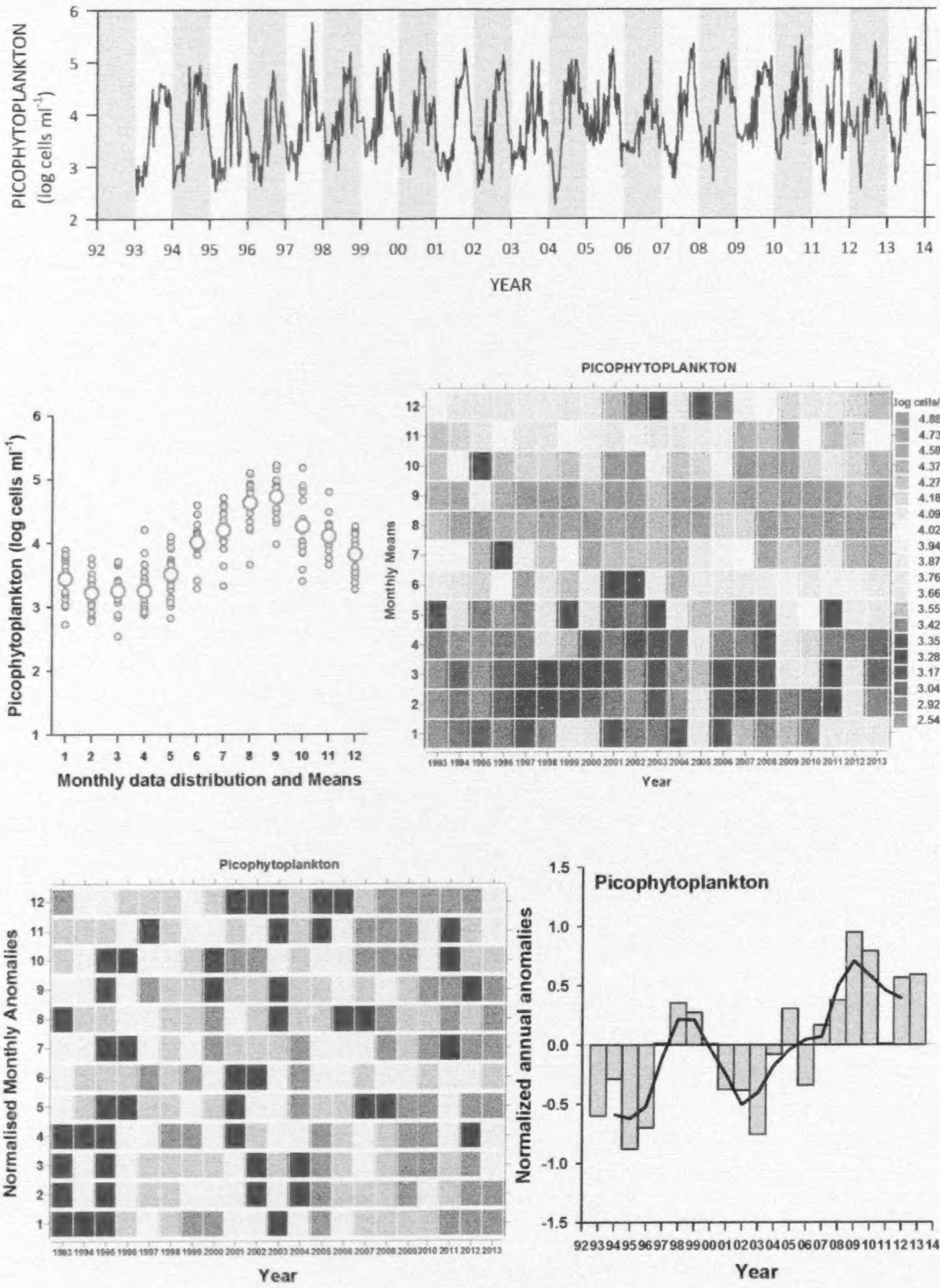
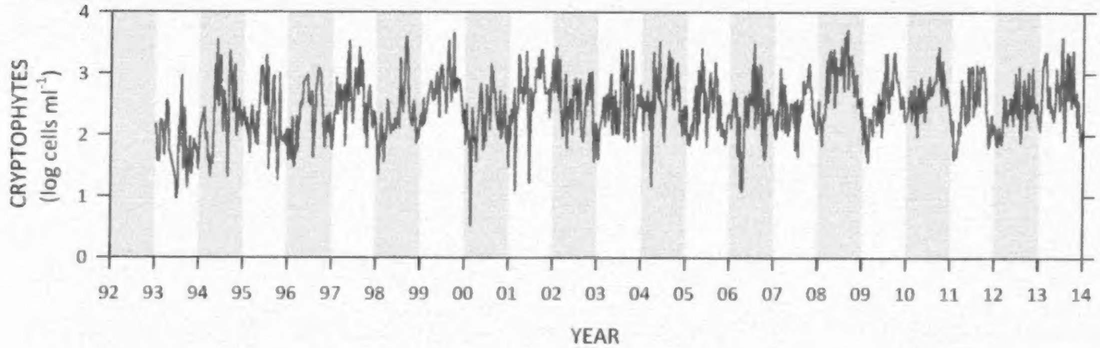
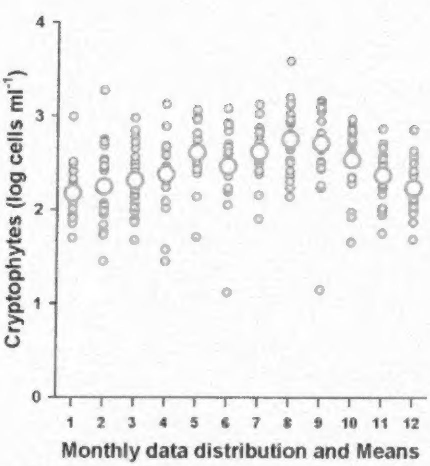
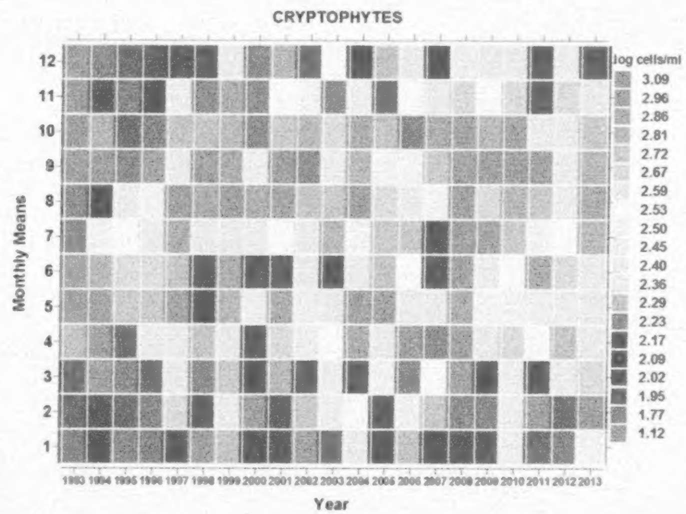
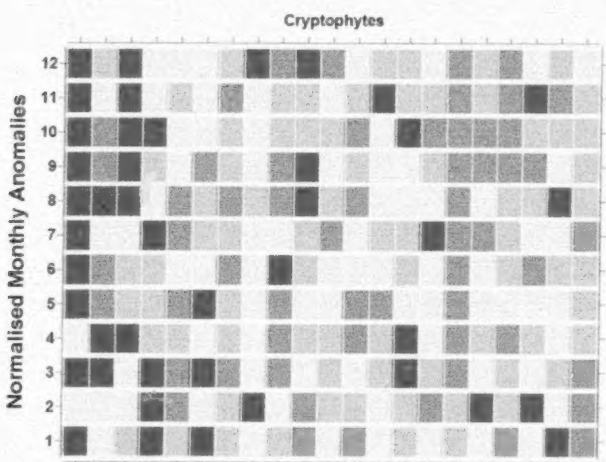

PICOPHYTOPLANKTON
(log cells ml^{-1})
YEAR
PICOPHYTOPLANKTON
Picophytoplankton (log cells ml^{-1})
Monthly data distribution and Means
Monthly Means
log cells/ml
Year
Picophytoplankton
Normalised Monthly Anomalies
Year
Picophytoplankton
Normalized annual anomalies
Year

Figure 21


CRYPTOPHYTES
(log cells ml-1)
YEAR


Cryptophytes (log cells ml-1)
Monthly data distribution and Means


CRYPTOPHYTES
Monthly Means
Year
log cells/ml
3.09
2.96
2.86
2.81
2.72
2.67
2.59
2.53
2.50
2.45
2.40
2.36
2.29
2.23
2.17
2.09
2.02
1.95
1.77
1.12


Cryptophytes
Normalised Monthly Anomalies
Year

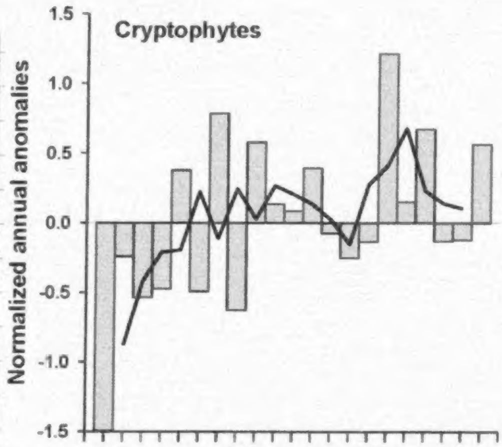

Cryptophytes
Normalized annual anomalies
Year

Figure 22

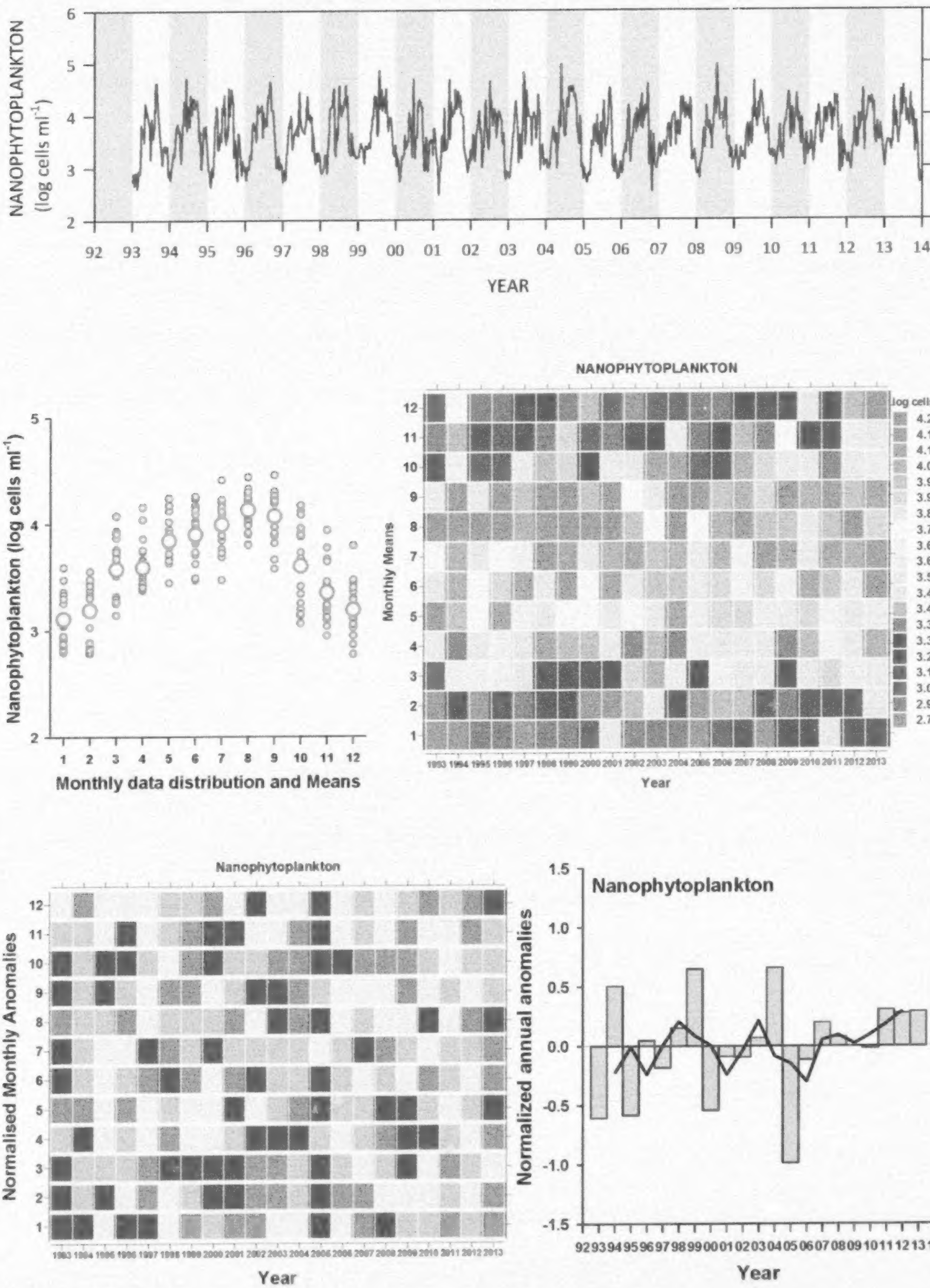

NANOPHYTOPLANKTON
(log cells ml^{-1})
YEAR
Nanophytoplankton (log cells ml^{-1})
Monthly data distribution and Means
NANOPHYTOPLANKTON
Monthly Means
log cells/ml
4.25
4.19
4.11
4.03
3.96
3.91
3.86
3.76
3.68
3.64
3.54
3.45
3.40
3.34
3.30
3.22
3.15
3.06
2.91
2.77
Year
Nanophytoplankton
Normalised Monthly Anomalies
Year
Nanophytoplankton
Normalized annual anomalies
Year

Figure 23

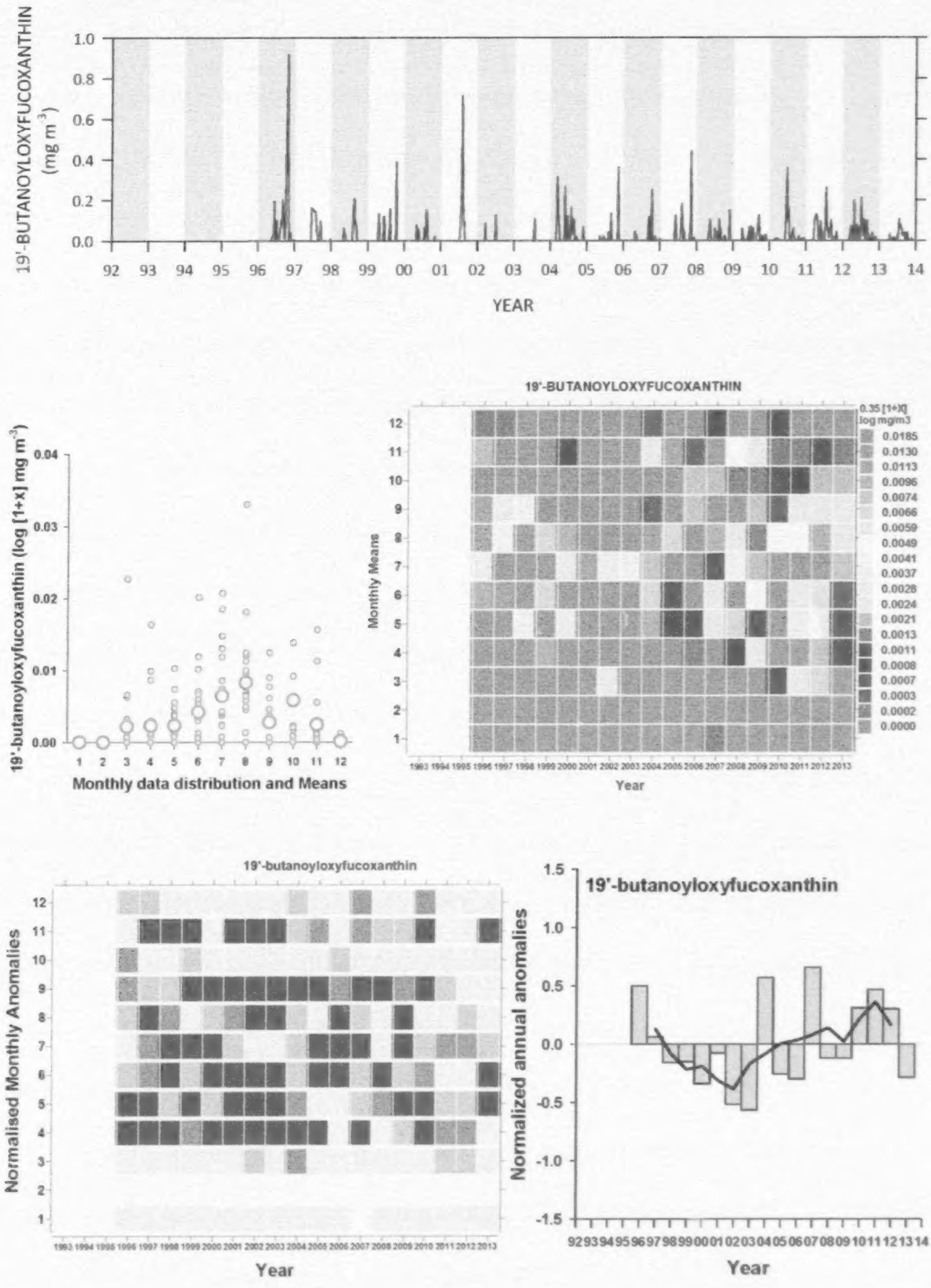

19'-BUTANOYLOXYFUCOXANTHIN (mg m^{-3})
YEAR
19'-butanoyloxyfucoxanthin (log [1+x] mg m^{-3})
Monthly data distribution and Means
19'-BUTANOYLOXYFUCOXANTHIN
Monthly Means
0.35 [1+X] log mg/m3
Year
19'-butanoyloxyfucoxanthin
Normalised Monthly Anomalies
Year
19'-butanoyloxyfucoxanthin
Normalized annual anomalies
Year

Figure 24

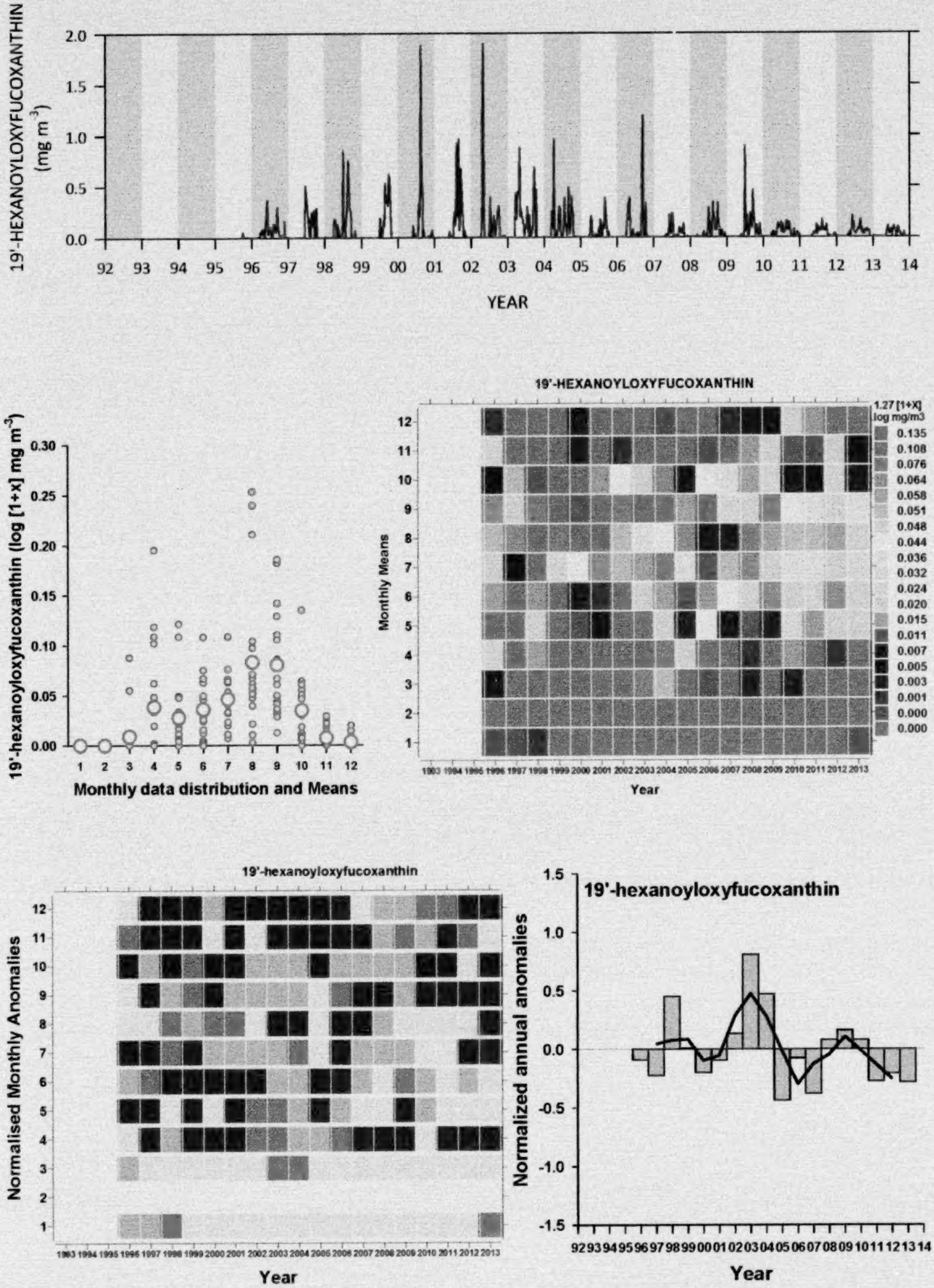

19'-HEXANOYLOXYFUCOXANTHIN
(mg m^{-3})
YEAR
19'-hexanoyloxyfucoxanthin (log [1+x] mg m^{-3})
Monthly data distribution and Means
19'-HEXANOYLOXYFUCOXANTHIN
Monthly Means
Year
19'-hexanoyloxyfucoxanthin
Normalised Monthly Anomalies
Year
19'-hexanoyloxyfucoxanthin
Normalized annual anomalies
Year

Figure 25

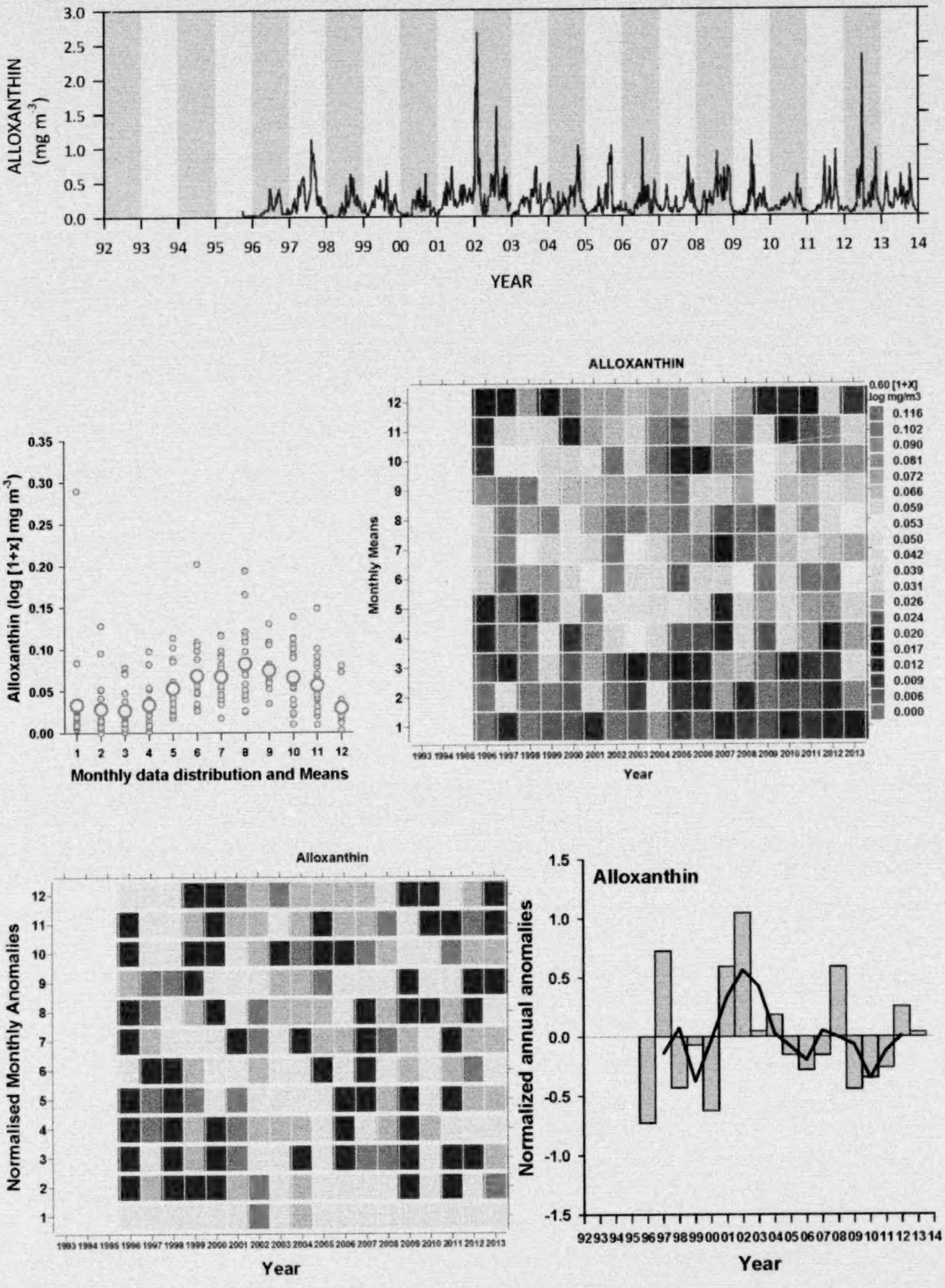

ALLOXANTHIN (mg m^{-3})
YEAR
ALLOXANTHIN
Monthly Means
Year
0.60 [1+X] log mg/m3
Alloxanthin (log [1+x] mg m^{-3})
Monthly data distribution and Means
Alloxanthin
Normalised Monthly Anomalies
Year
Alloxanthin
Normalized annual anomalies
Year

Figure 26

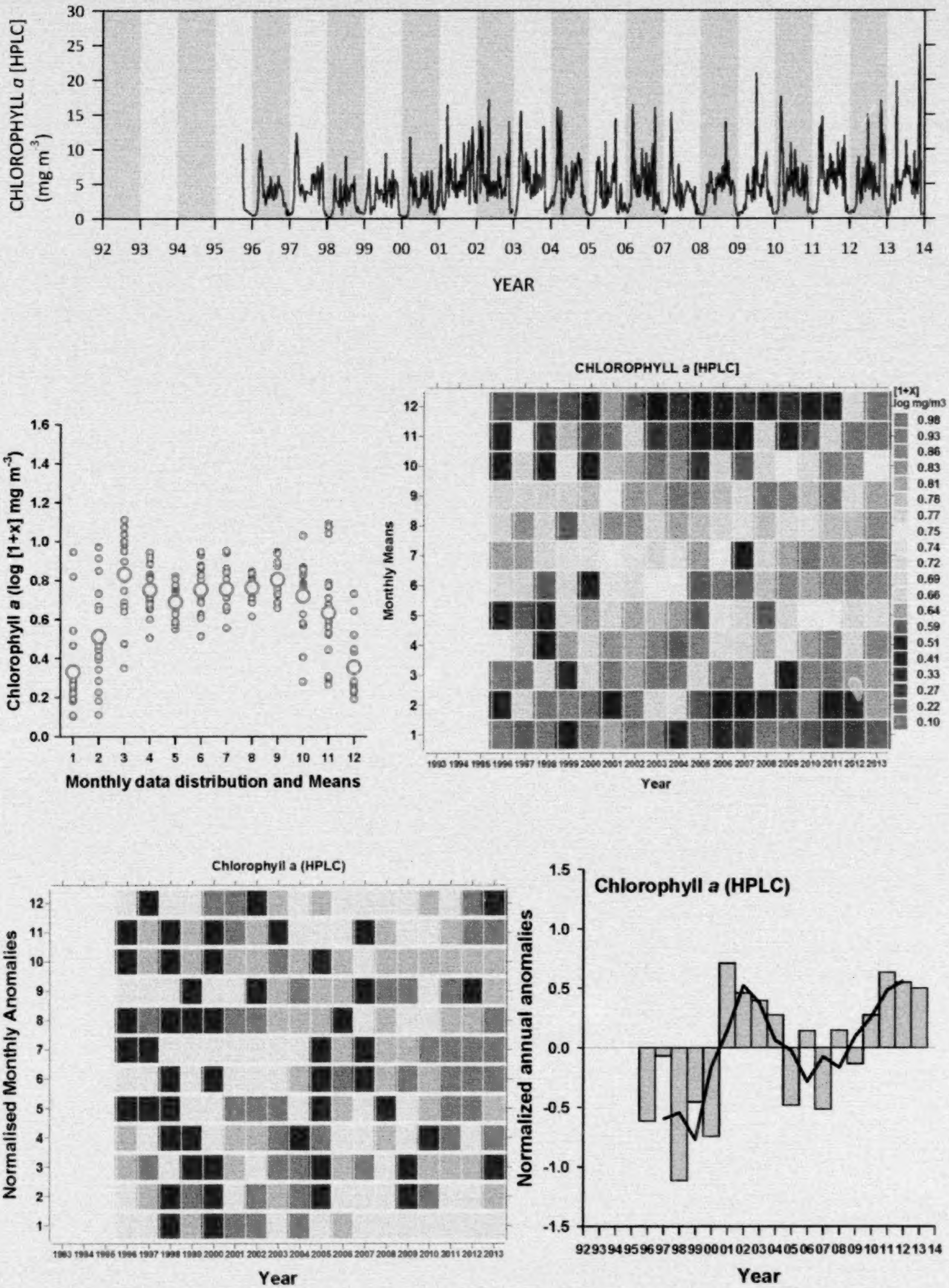

CHLOROPHYLL a [HPLC]
(mg m^{-3})
YEAR
Chlorophyll a (log [1+x] mg m^{-3})
Monthly data distribution and Means
CHLOROPHYLL a [HPLC]
Monthly Means
Year
[1+X] log mg/m3
Chlorophyll a (HPLC)
Normalised Monthly Anomalies
Year
Chlorophyll a (HPLC)
Normalized annual anomalies
Year

Figure 27

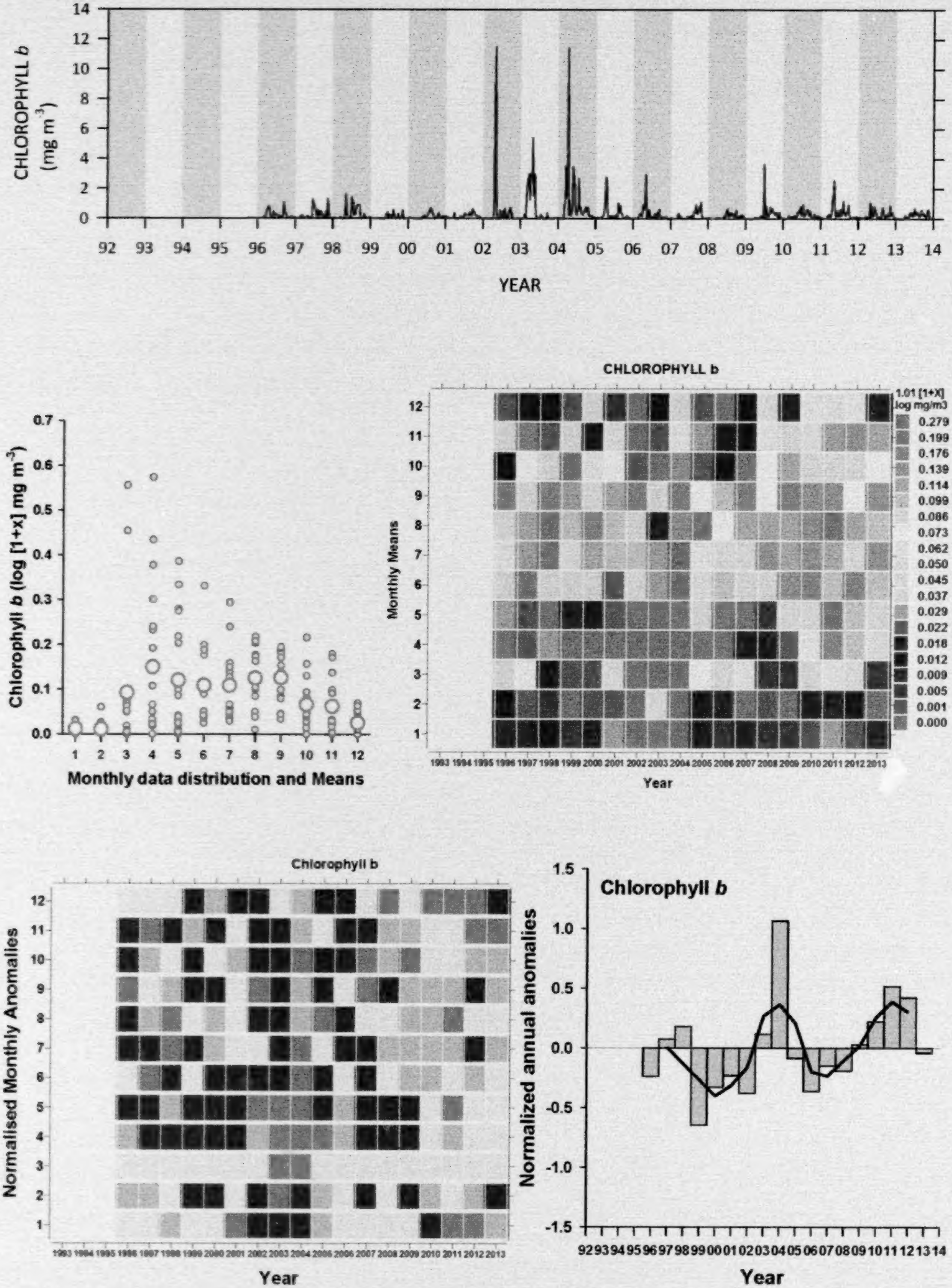

CHLOROPHYLL b (mg m-3)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Chlorophyll b (log [1+x] mg m-3)
Monthly data distribution and Means
CHLOROPHYLL b
Monthly Means
Year
1.01 [1+X] log mg/m3
0.279
0.199
0.176
0.139
0.114
0.099
0.086
0.073
0.062
0.050
0.045
0.037
0.029
0.022
0.018
0.012
0.009
0.005
0.001
0.000
Chlorophyll b
Normalised Monthly Anomalies
Year
Chlorophyll b
Normalized annual anomalies
Year

Figure 28

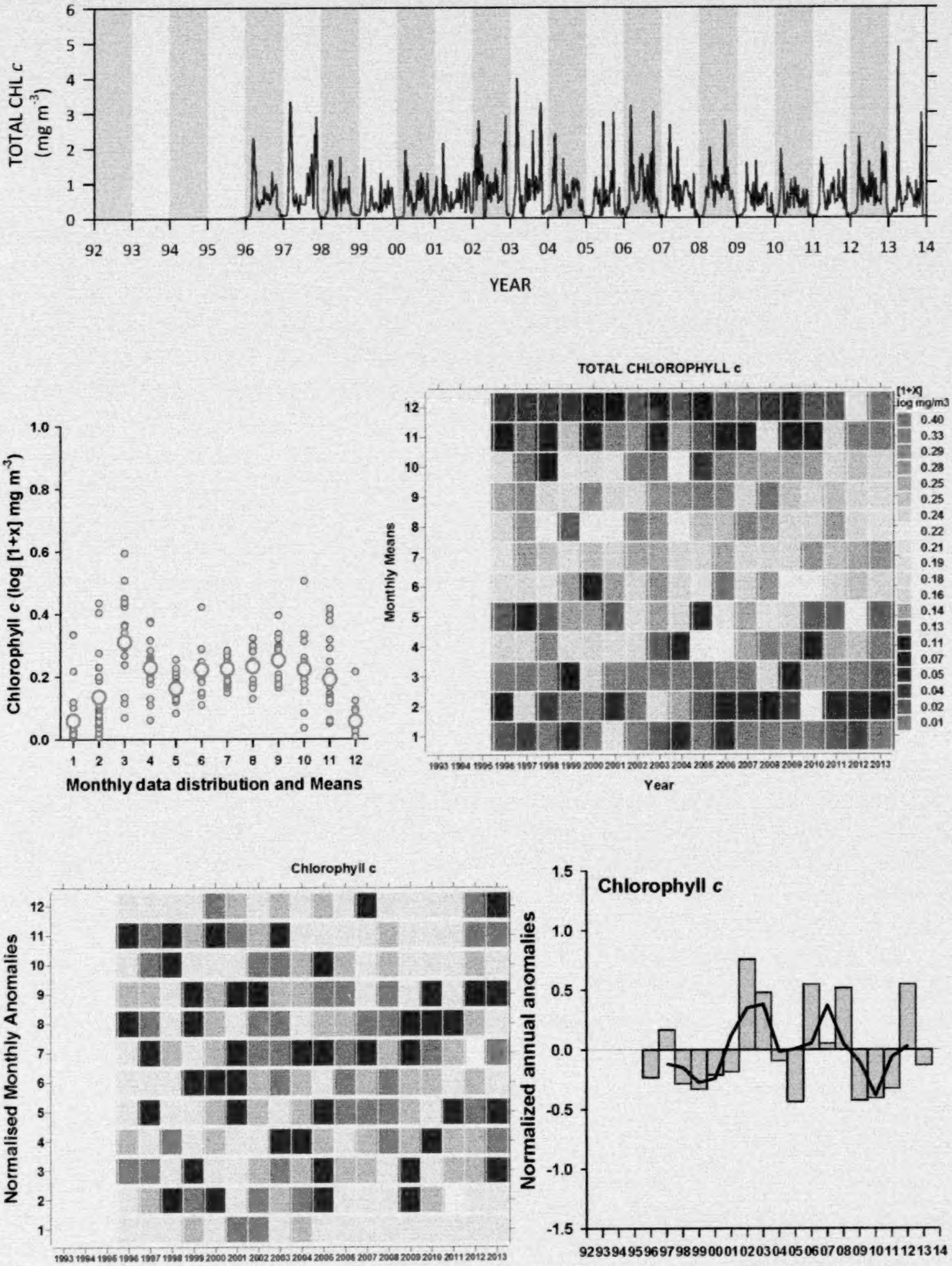
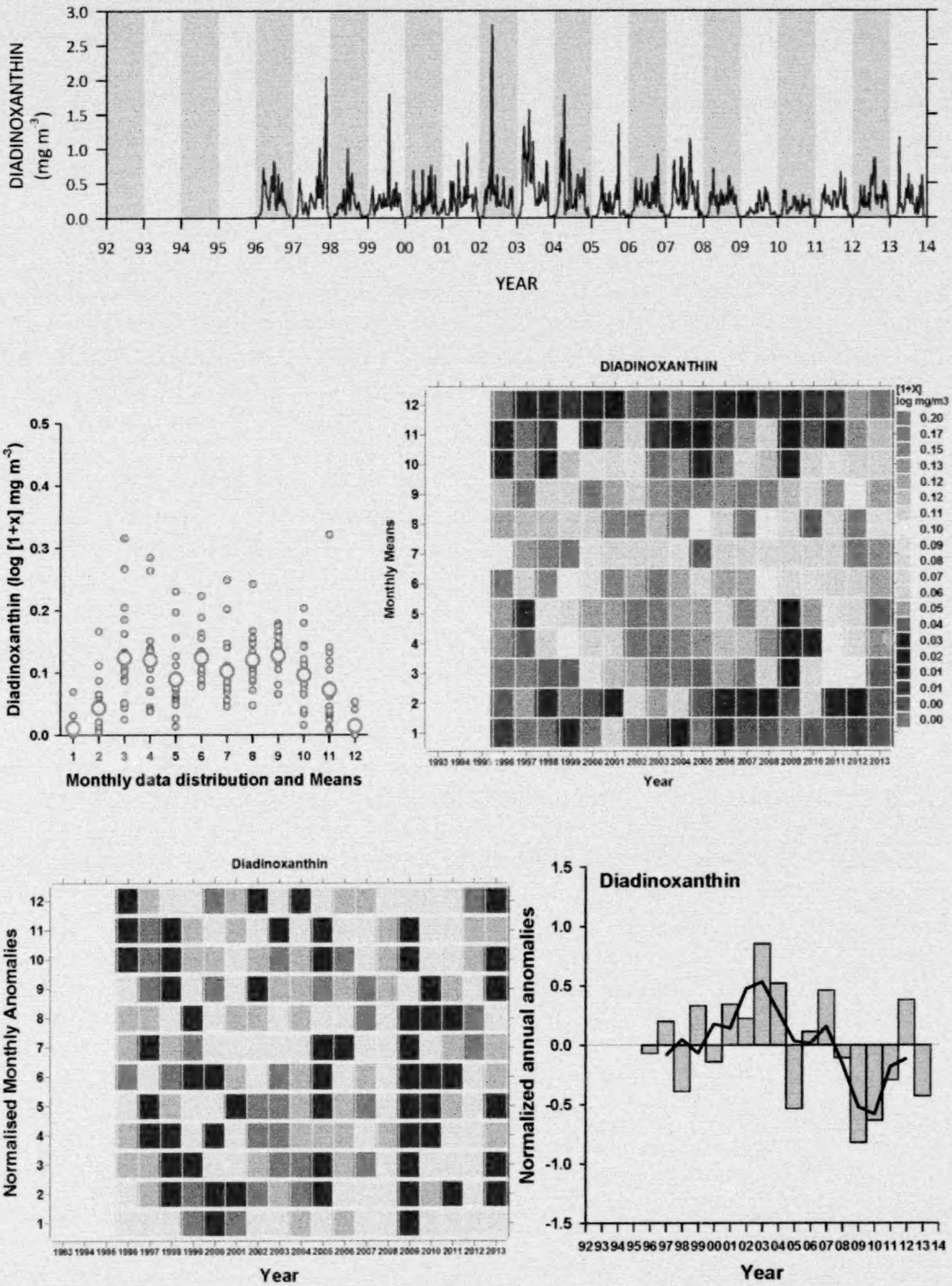
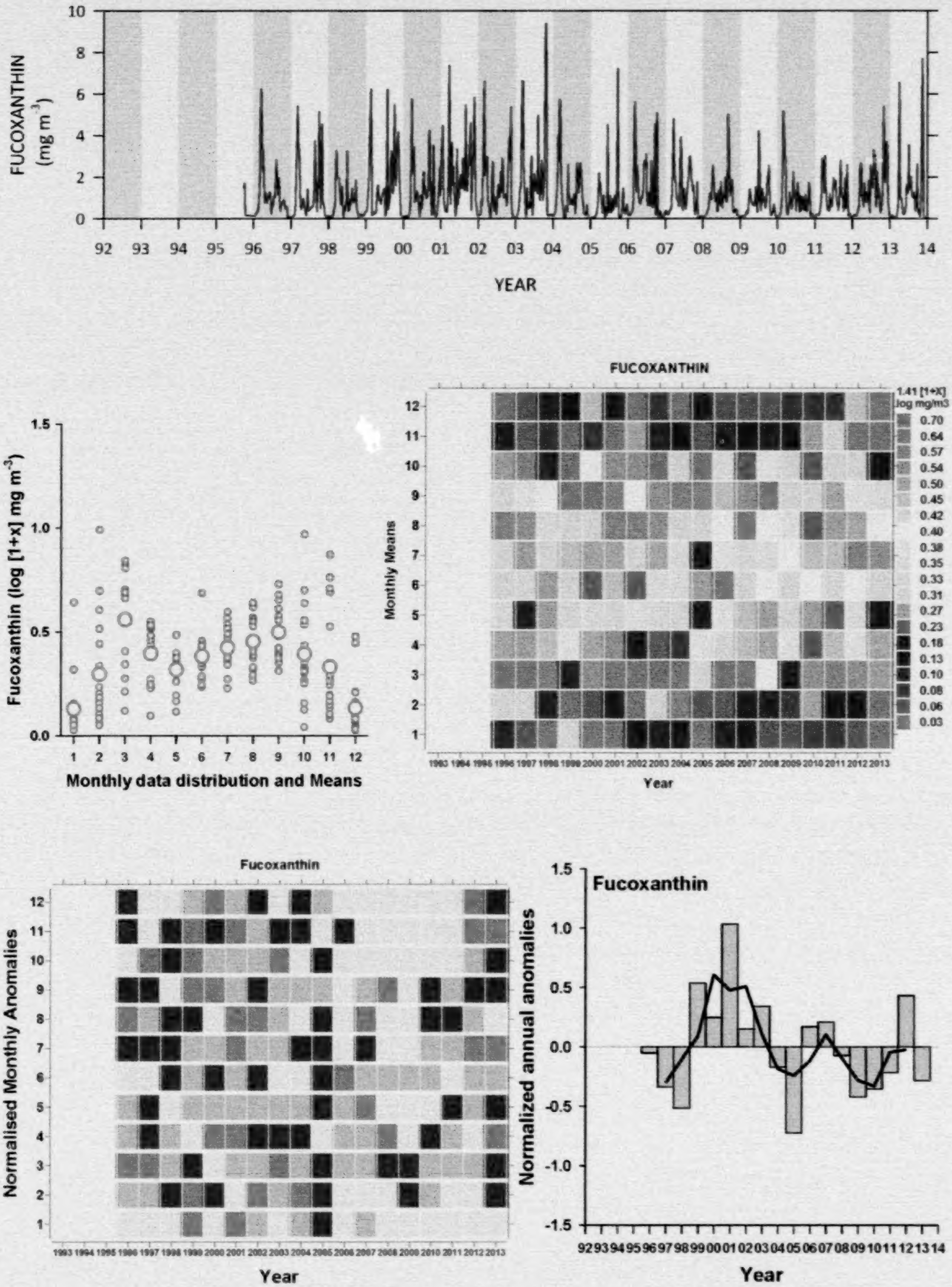

TOTAL CHL c (mg m^{-3})
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Chlorophyll c (log [1+x] mg m^{-3})
Monthly data distribution and Means
TOTAL CHLOROPHYLL c
Monthly Means
Year
[1+X] log mg/m3
0.40 0.33 0.29 0.28 0.25 0.25 0.24 0.22 0.21 0.19 0.18 0.16 0.14 0.13 0.11 0.07 0.05 0.04 0.02 0.01
Chlorophyll c
Normalised Monthly Anomalies
Year
Chlorophyll c
Normalized annual anomalies
Year

Figure 29



DIADINOXANTHIN (mg m^{-3})
3.0
2.5
2.0
1.5
1.0
0.5
0.0
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
Diadinoxanthin (log [1+x] mg m^{-3})
0.5
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Monthly data distribution and Means
DIADINOXANTHIN
Monthly Means
[1+X] log mg/m3
0.20
0.17
0.15
0.13
0.12
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.01
0.00
0.00
Year
Diadinoxanthin
Normalised Monthly Anomalies
Year
Diadinoxanthin
Normalized annual anomalies
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 30



FUCOXANTHIN (mg m^{-3})
YEAR
FUCOXANTHIN
Monthly Means
Year
1.41 [1+X] log mg/m3
Fucoxanthin (log [1+x] mg m^{-3})
Monthly data distribution and Means
Fucoxanthin
Normalised Monthly Anomalies
Year
Fucoxanthin
Normalized annual anomalies
Year

Figure 31

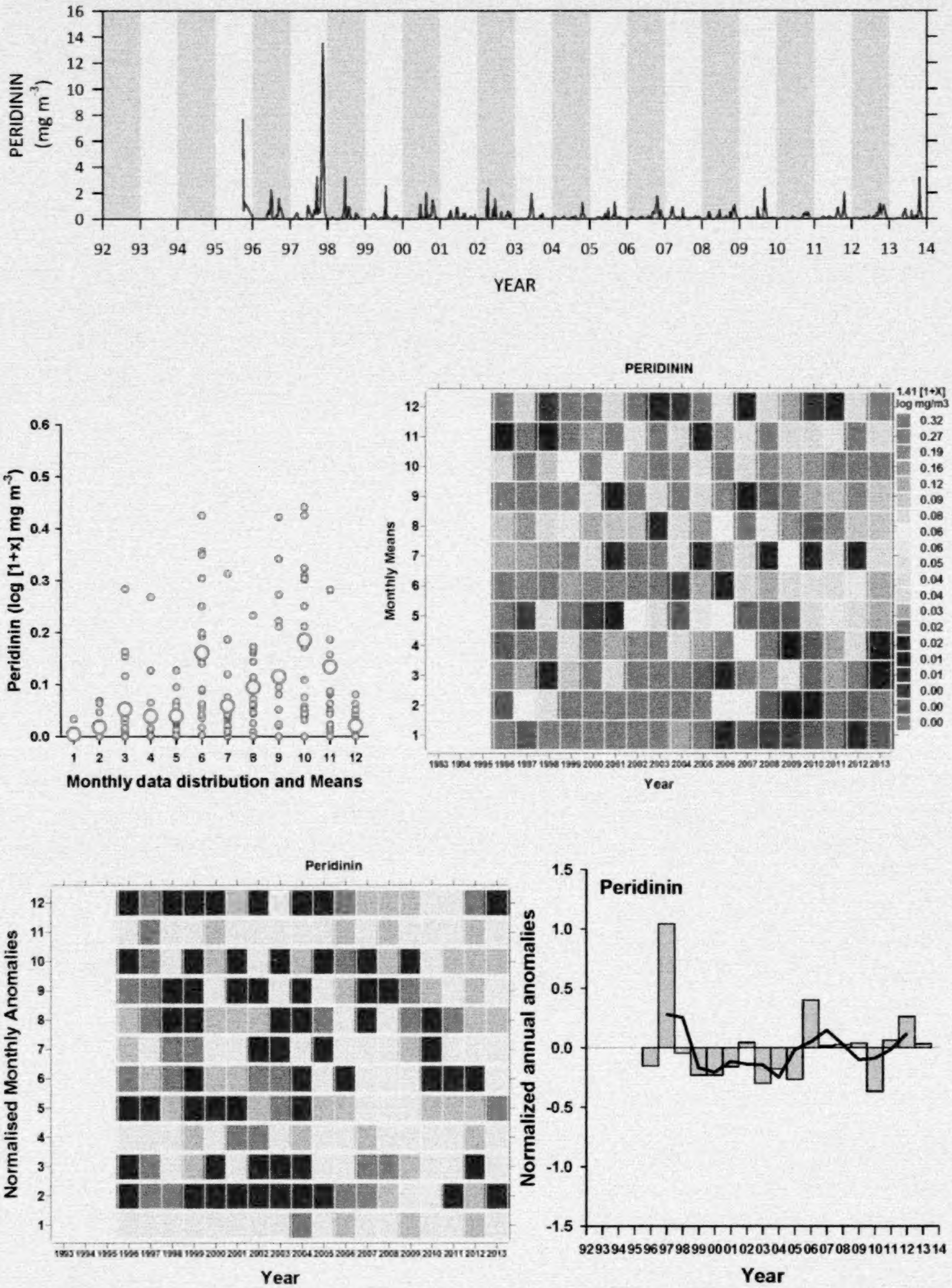

PERIDININ (mg m^{-3})
YEAR
Peridinin (log [1+x] mg m^{-3})
Monthly data distribution and Means
PERIDININ
Monthly Means
Year
Peridinin
Normalised Monthly Anomalies
Year
Peridinin
Normalized annual anomalies
Year

Figure 32

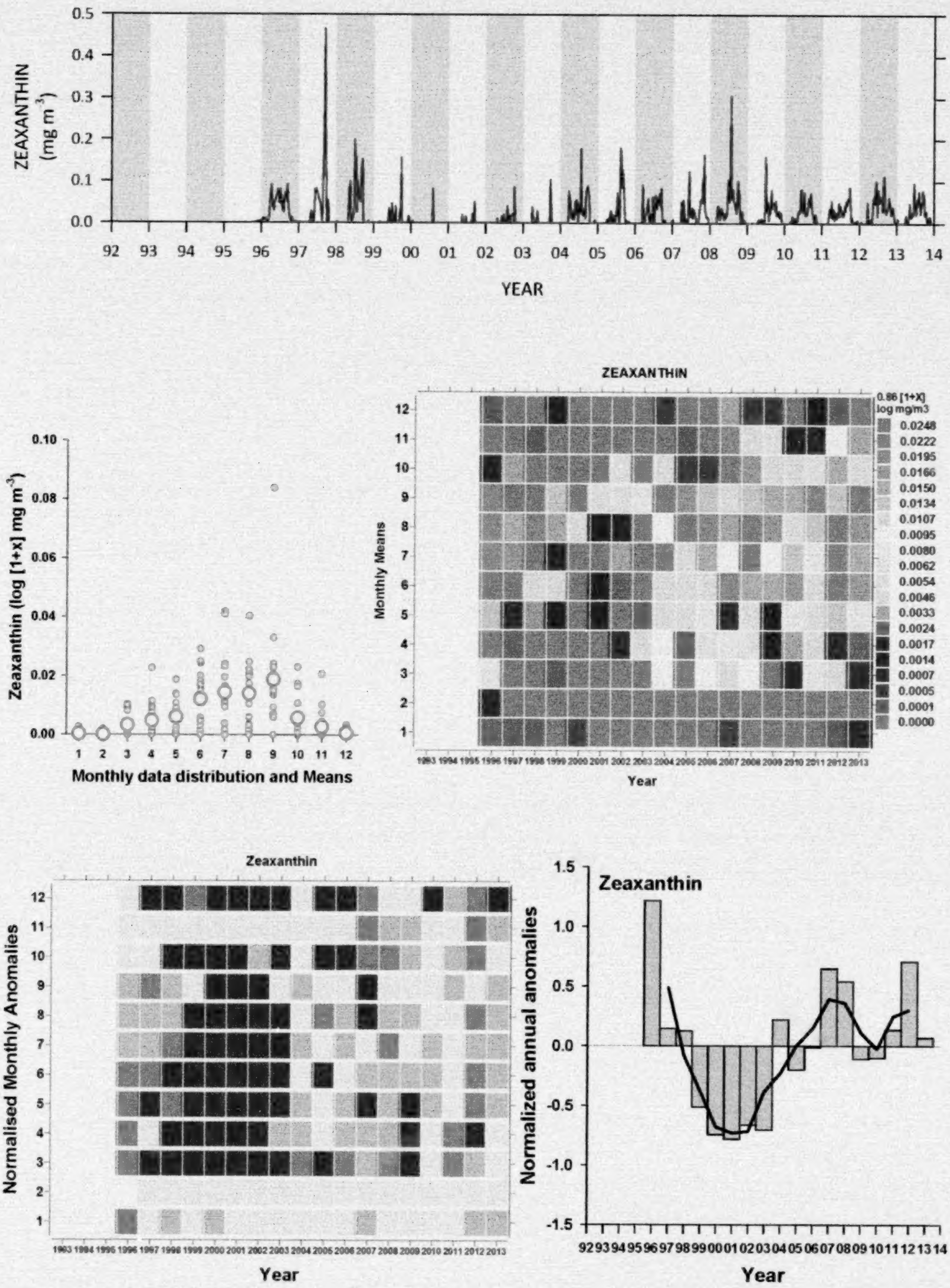

ZEAXANTHIN (mg m^{-3})
YEAR
ZEAXANTHIN
Monthly Means
Year
0.86 [1+X] log mg/m3
Zeaxanthin (log [1+x] mg m^{-3})
Monthly data distribution and Means
Zeaxanthin
Normalised Monthly Anomalies
Year
Zeaxanthin
Normalized annual anomalies
Year

Figure 33

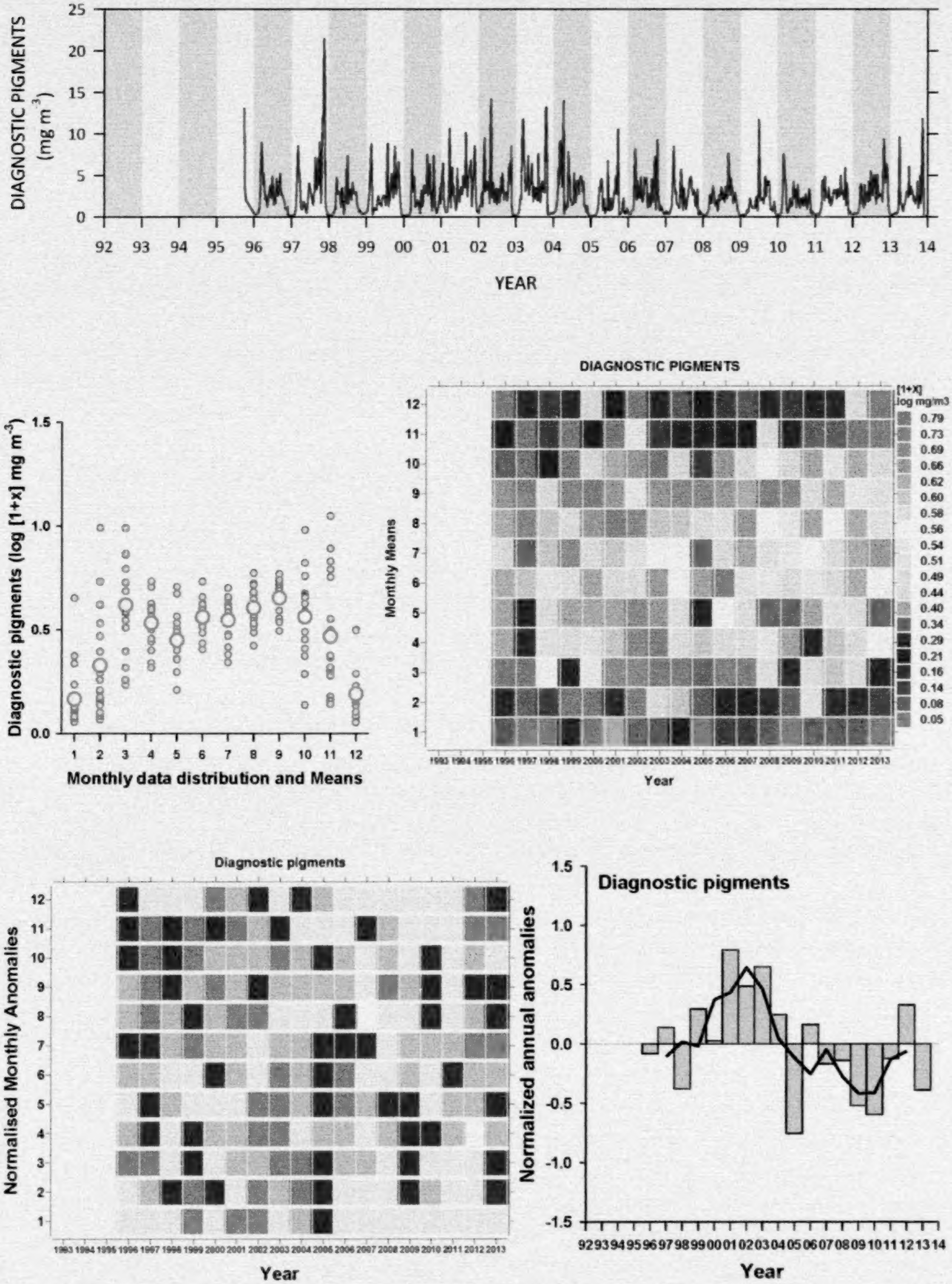
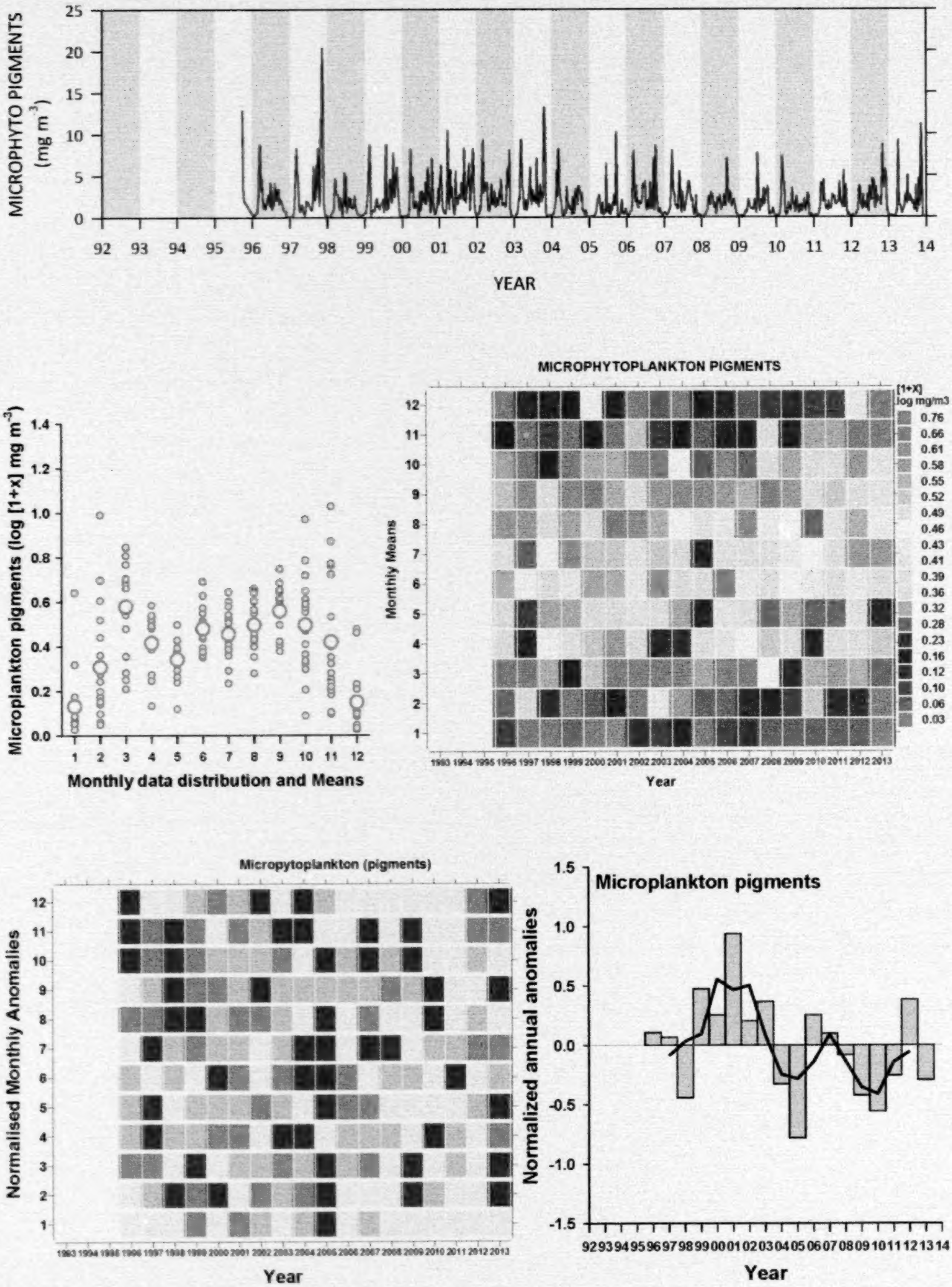

DIAGNOSTIC PIGMENTS (mg m-3)
YEAR
Diagnostic pigments (log [1+x] mg m-3)
Monthly data distribution and Means
DIAGNOSTIC PIGMENTS
Monthly Means
[1+X] log mg/m3
Year
Diagnostic pigments
Normalised Monthly Anomalies
Year
Diagnostic pigments
Normalized annual anomalies
Year

Figure 34



MICROPHYTO PIGMENTS (mg m^-3)
YEAR
MICROPHYTOPLANKTON PIGMENTS
Microplankton pigments (log [1+x] mg m^-3)
Monthly data distribution and Means
Monthly Means
Year
[1+X] log mg/m3
Micropytoplankton (pigments)
Normalised Monthly Anomalies
Year
Microplankton pigments
Normalized annual anomalies
Year

Figure 35

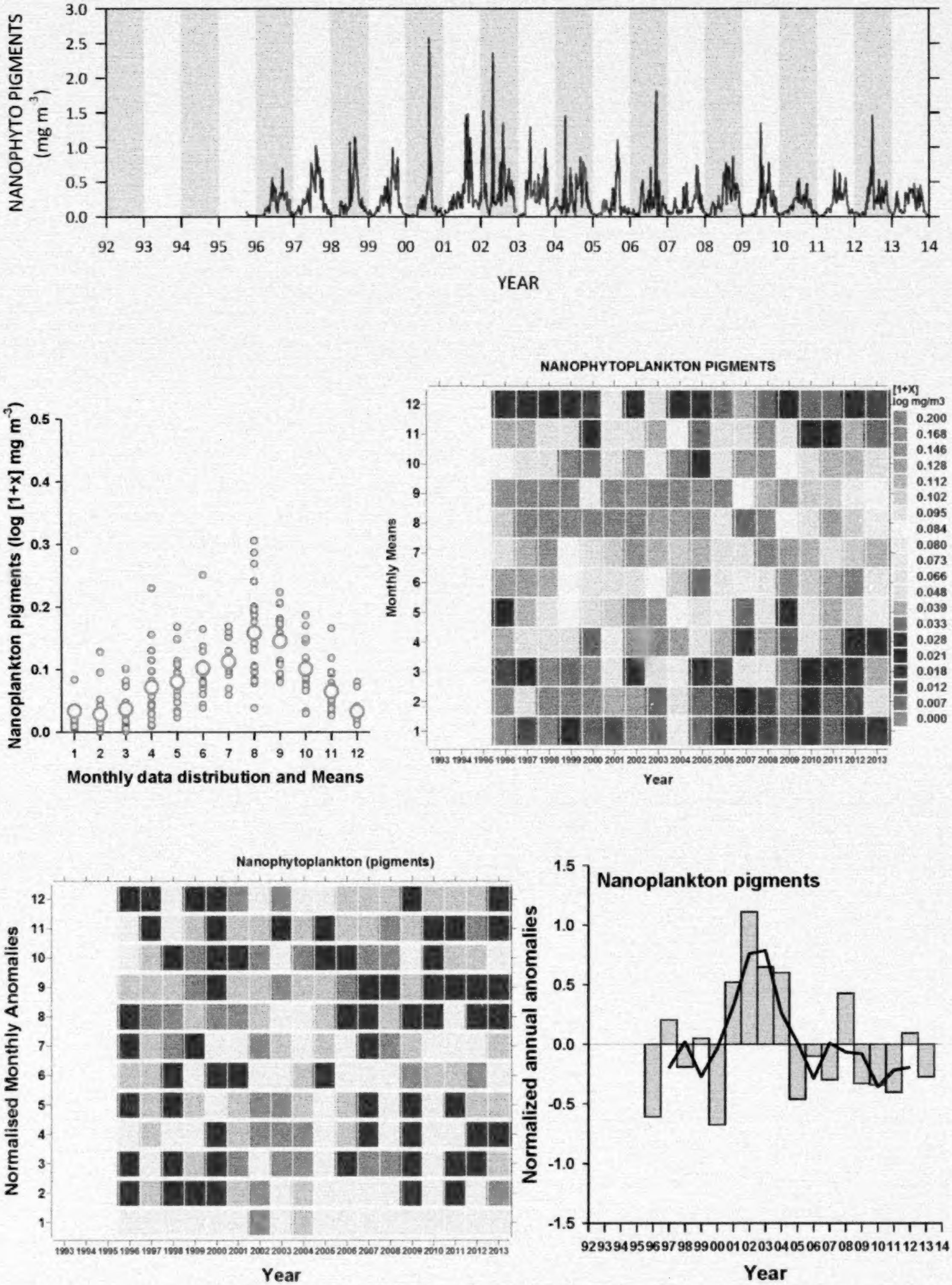
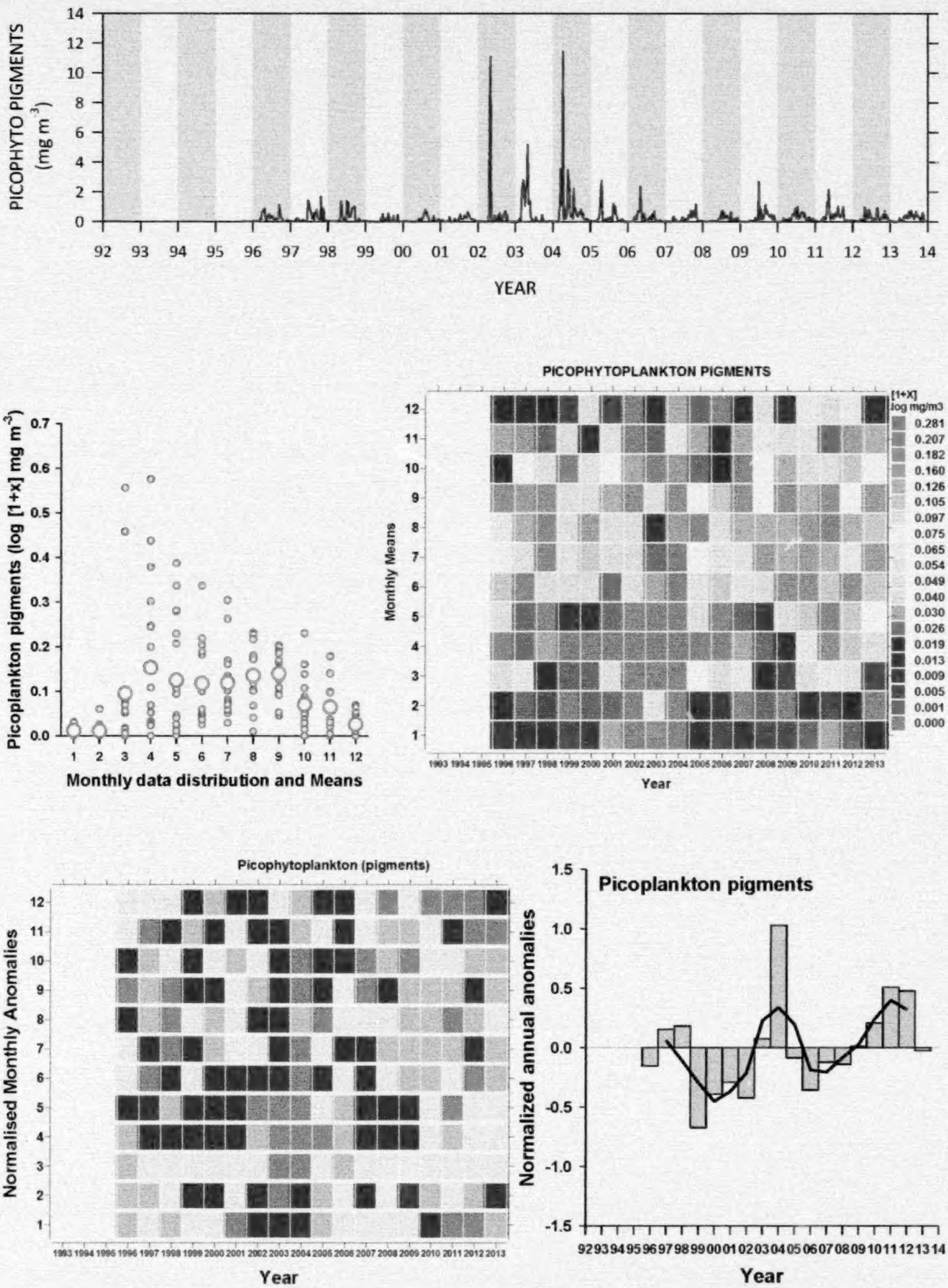

NANOPHYTO PIGMENTS (mg m^{-3})
YEAR
Nanoplankton pigments (log [1+x] mg m^{-3})
Monthly data distribution and Means
NANOPHYTOPLANKTON PIGMENTS
[1+X] log mg/m3
Monthly Means
Year
Nanophytoplankton (pigments)
Normalised Monthly Anomalies
Year
Nanoplankton pigments
Normalized annual anomalies
Year

Figure 36



PICOPHYTO PIGMENTS (mg m^{-3})
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Picoplankton pigments (log [1+x] mg m^{-3})
Monthly data distribution and Means
PICOPHYTOPLANKTON PIGMENTS
Monthly Means
[1+X] log mg/m3
0.281
0.207
0.182
0.160
0.126
0.105
0.097
0.075
0.065
0.054
0.049
0.040
0.030
0.026
0.019
0.013
0.009
0.005
0.001
0.000
Year
Picophytoplankton (pigments)
Normalised Monthly Anomalies
Year
Picoplankton pigments
Normalized annual anomalies
Year

Figure 37

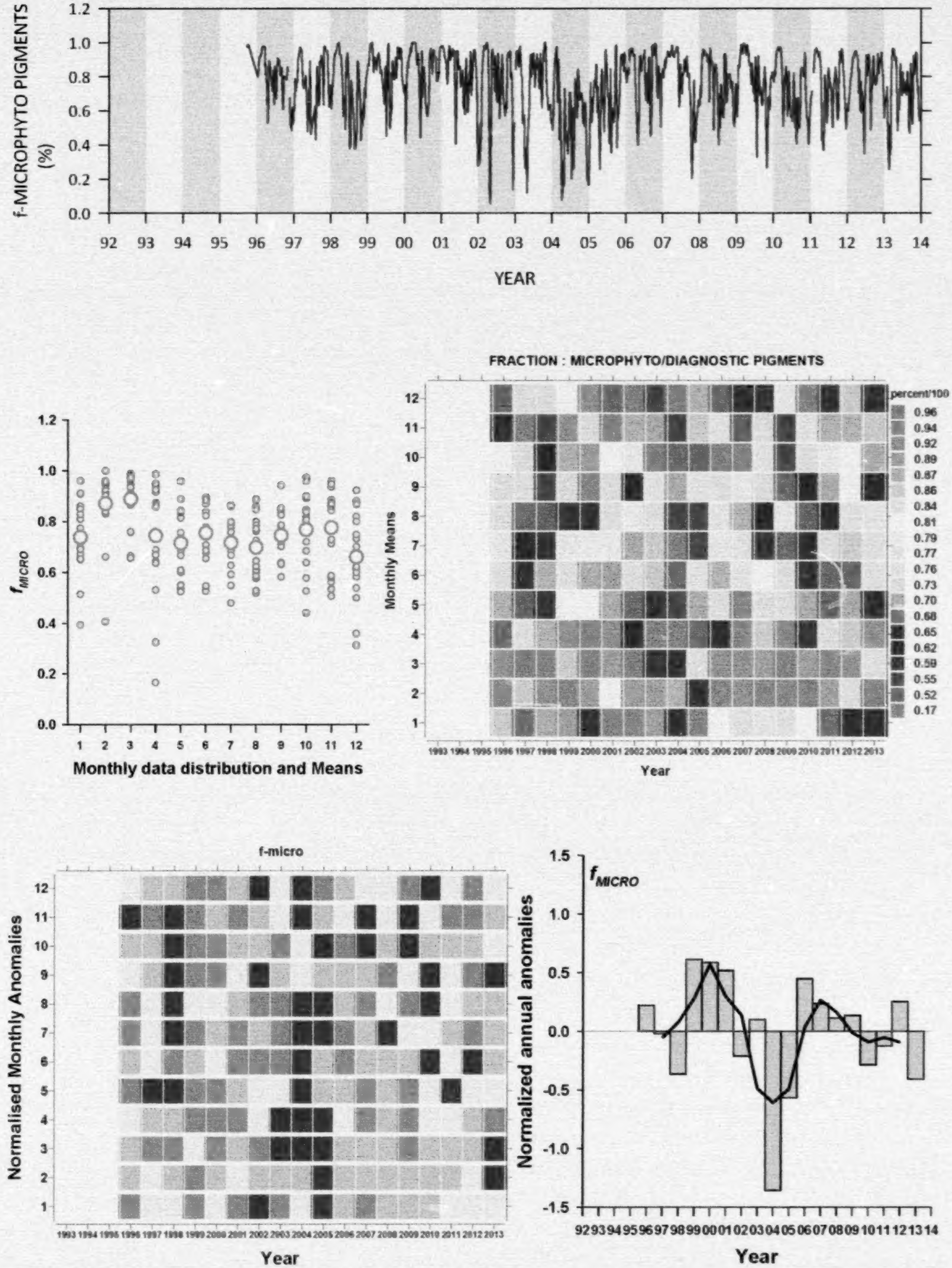

f-MICROPHYTO PIGMENTS (%)
YEAR
FRACTION : MICROPHYTO/DIAGNOSTIC PIGMENTS
f_{MICRO}
Monthly data distribution and Means
Monthly Means
Year
percent/100
f-micro
Normalised Monthly Anomalies
Year
f_{MICRO}
Normalized annual anomalies
Year

Figure 38

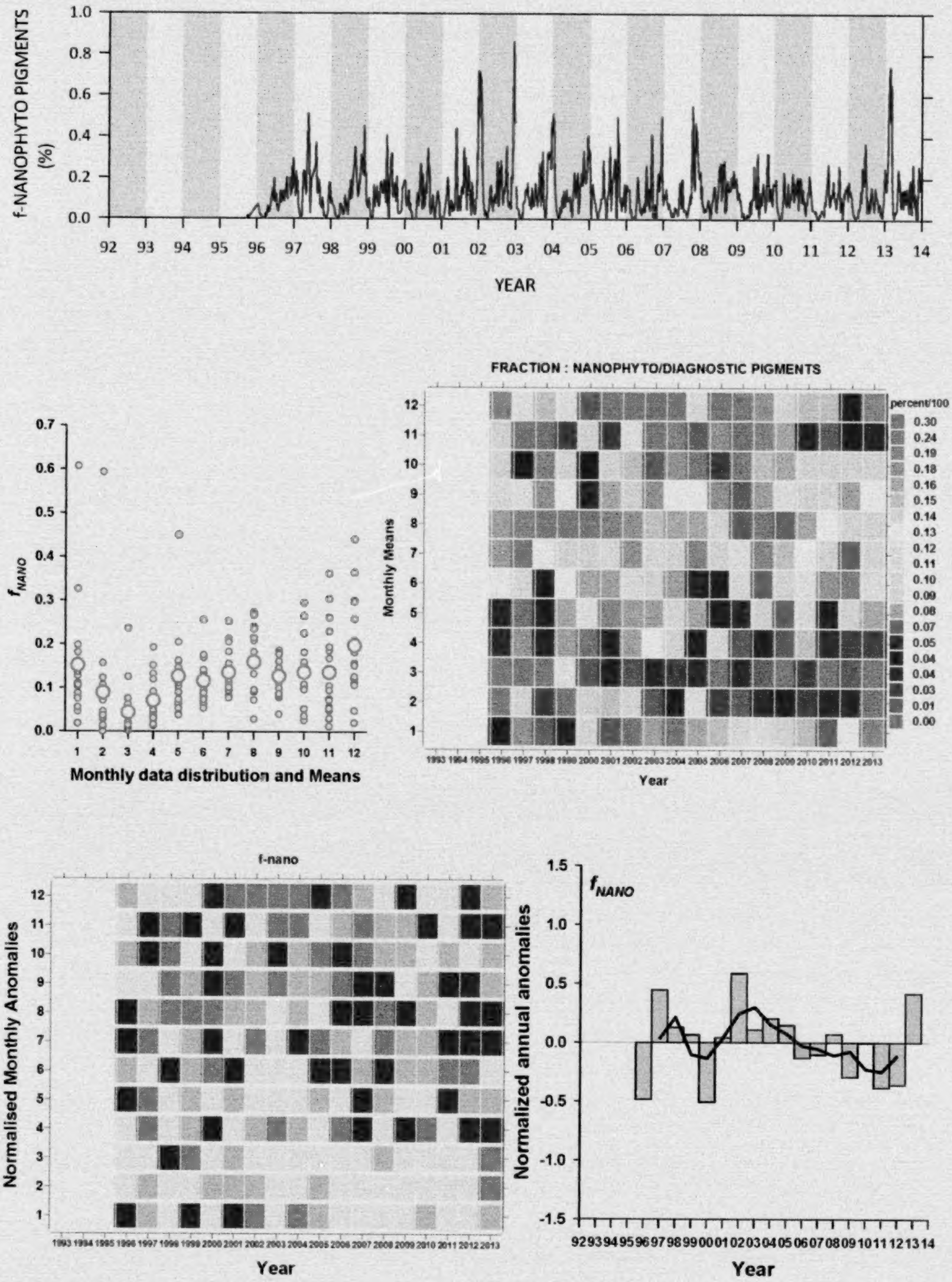

f-NANOPHYTO PIGMENTS
(%)
YEAR
f_{NANO}
Monthly data distribution and Means
FRACTION : NANOPHYTO/DIAGNOSTIC PIGMENTS
Monthly Means
percent/100
Year
f-nano
Normalised Monthly Anomalies
Year
f_{NANO}
Normalized annual anomalies
Year

Figure 39

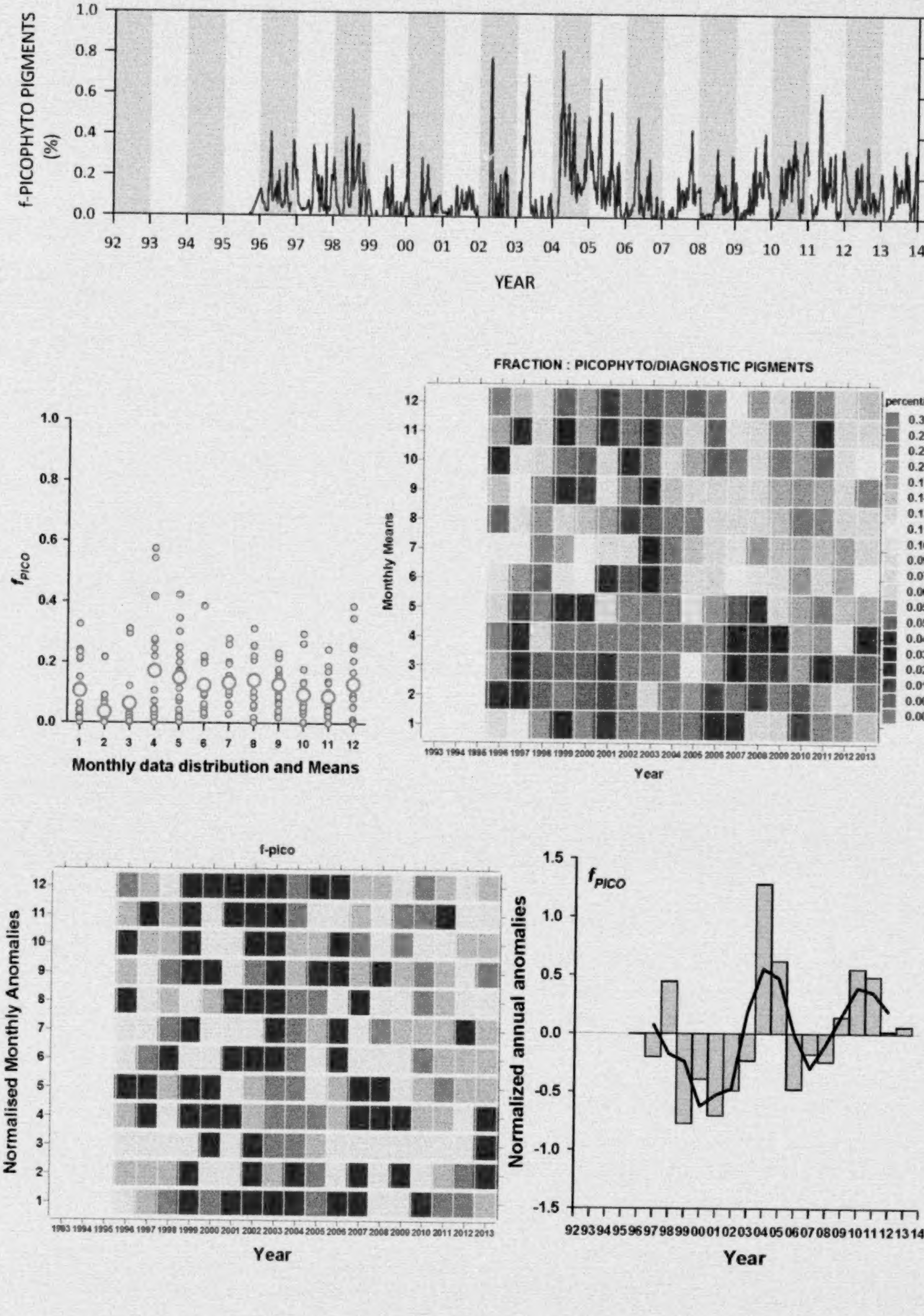

f-PICOPHYTO PIGMENTS (%)
YEAR
FRACTION : PICOPHYTO/DIAGNOSTIC PIGMENTS
percent/100
Monthly Means
Year
f_{PICO}
Monthly data distribution and Means
f-pico
Normalised Monthly Anomalies
Year
f_{PICO}
Normalized annual anomalies
Year

Figure 40

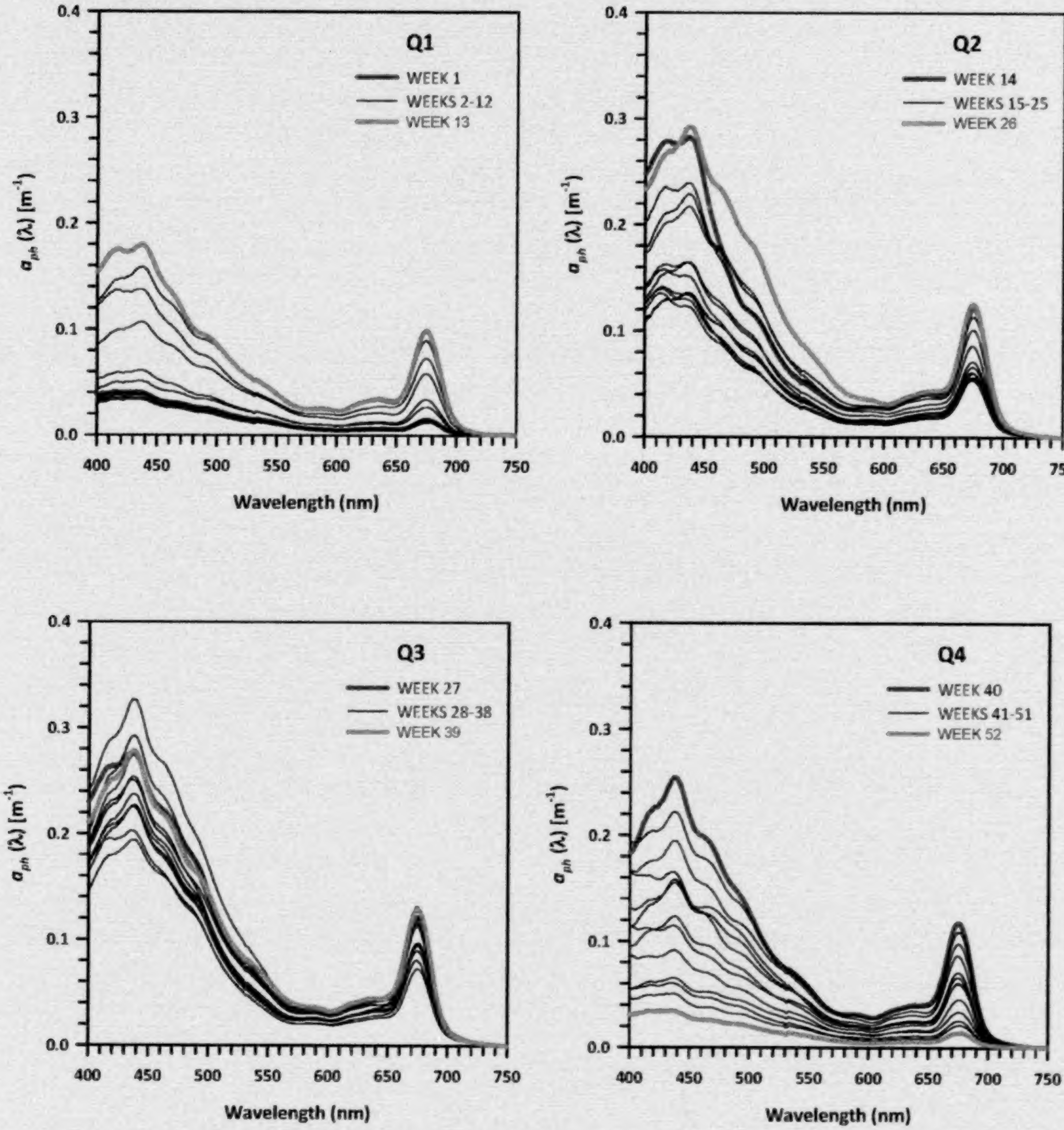
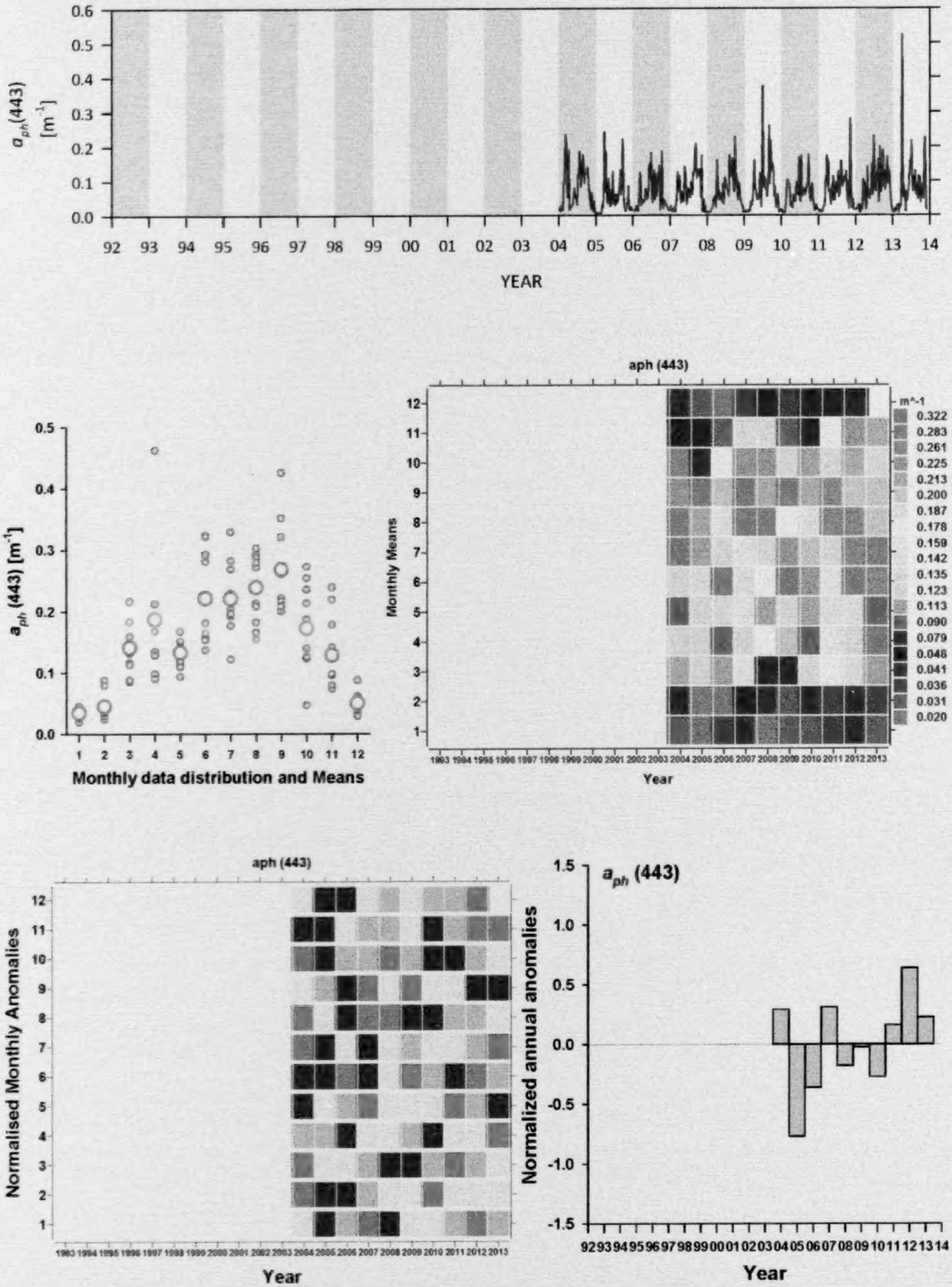

Q1
WEEK 1
WEEKS 2-12
WEEK 13
Q2
WEEK 14
WEEKS 15-25
WEEK 26
Q3
WEEK 27
WEEKS 28-38
WEEK 39
Q4
WEEK 40
WEEKS 41-51
WEEK 52
a_{ph} (λ) [m^{-1}]
Wavelength (nm)

Figure 41



$a_{ph}(443)$ [m^{-1}]
YEAR
a_{ph} (443) [m^{-1}]
Monthly data distribution and Means
aph (443)
Monthly Means
Year
m^-1
0.322
0.283
0.261
0.225
0.213
0.200
0.187
0.178
0.159
0.142
0.135
0.123
0.113
0.090
0.079
0.048
0.041
0.036
0.031
0.020
aph (443)
Normalised Monthly Anomalies
Year
a_{ph} (443)
Normalized annual anomalies
Year

Figure 42

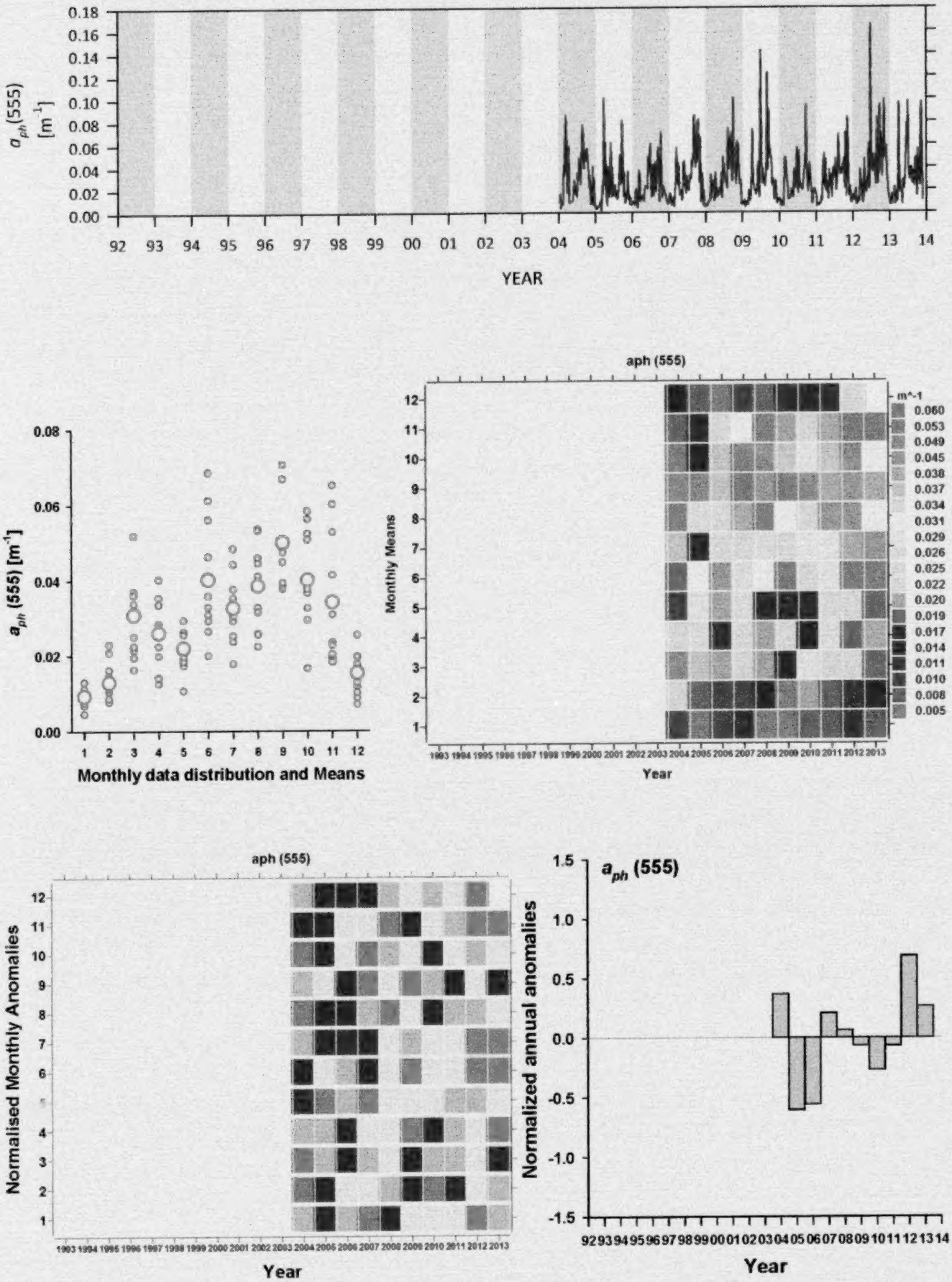
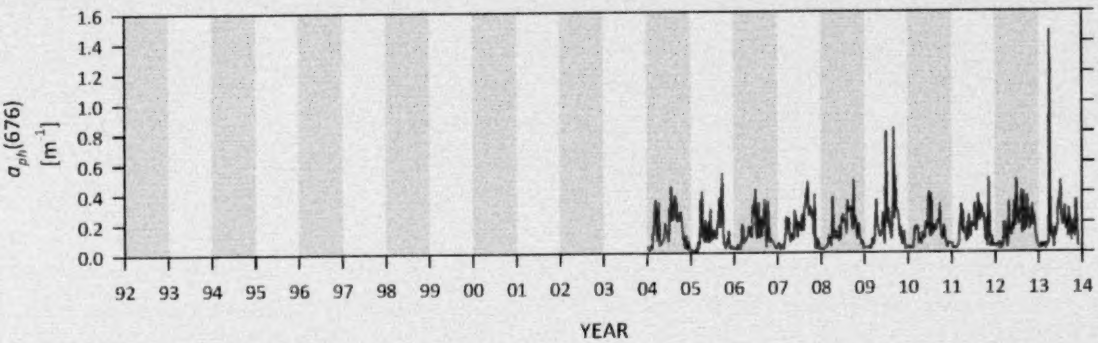
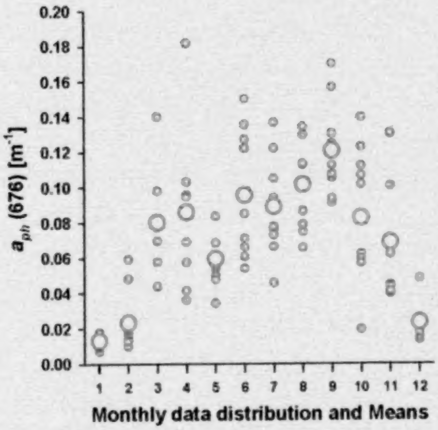

a_{ph}(555) [m^{-1}]
YEAR
a_{ph} (555) [m^{-1}]
Monthly data distribution and Means
aph (555)
Monthly Means
m^-1
0.060
0.053
0.049
0.045
0.038
0.037
0.034
0.031
0.029
0.026
0.025
0.022
0.020
0.019
0.017
0.014
0.011
0.010
0.008
0.005
Year
aph (555)
Normalised Monthly Anomalies
Year
a_{ph} (555)
Normalized annual anomalies
Year

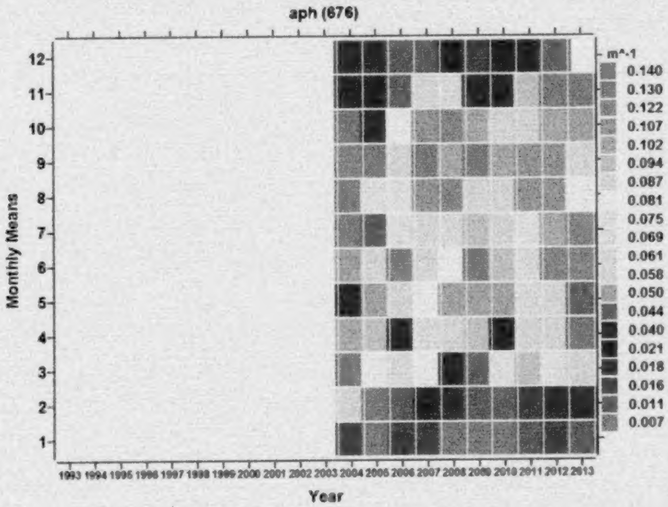
Figure 43



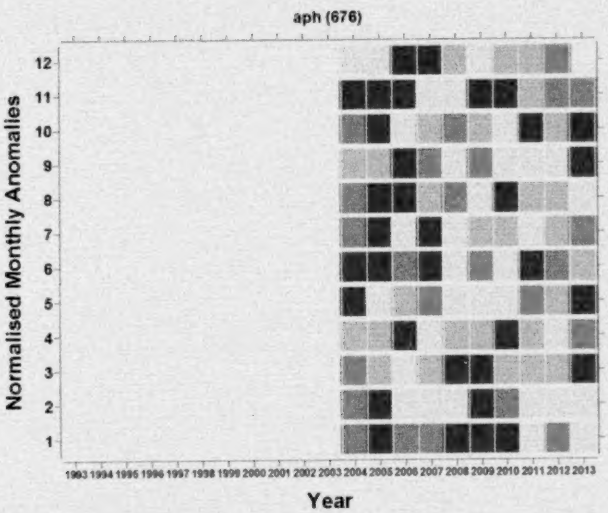
$a_{ph}(676)$ [m^{-1}]
YEAR



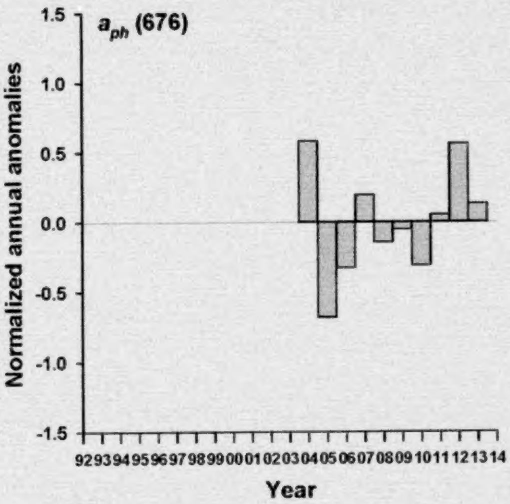
a_{ph} (676) [m^{-1}]
Monthly data distribution and Means



aph (676)
Monthly Means
Year
m^-1

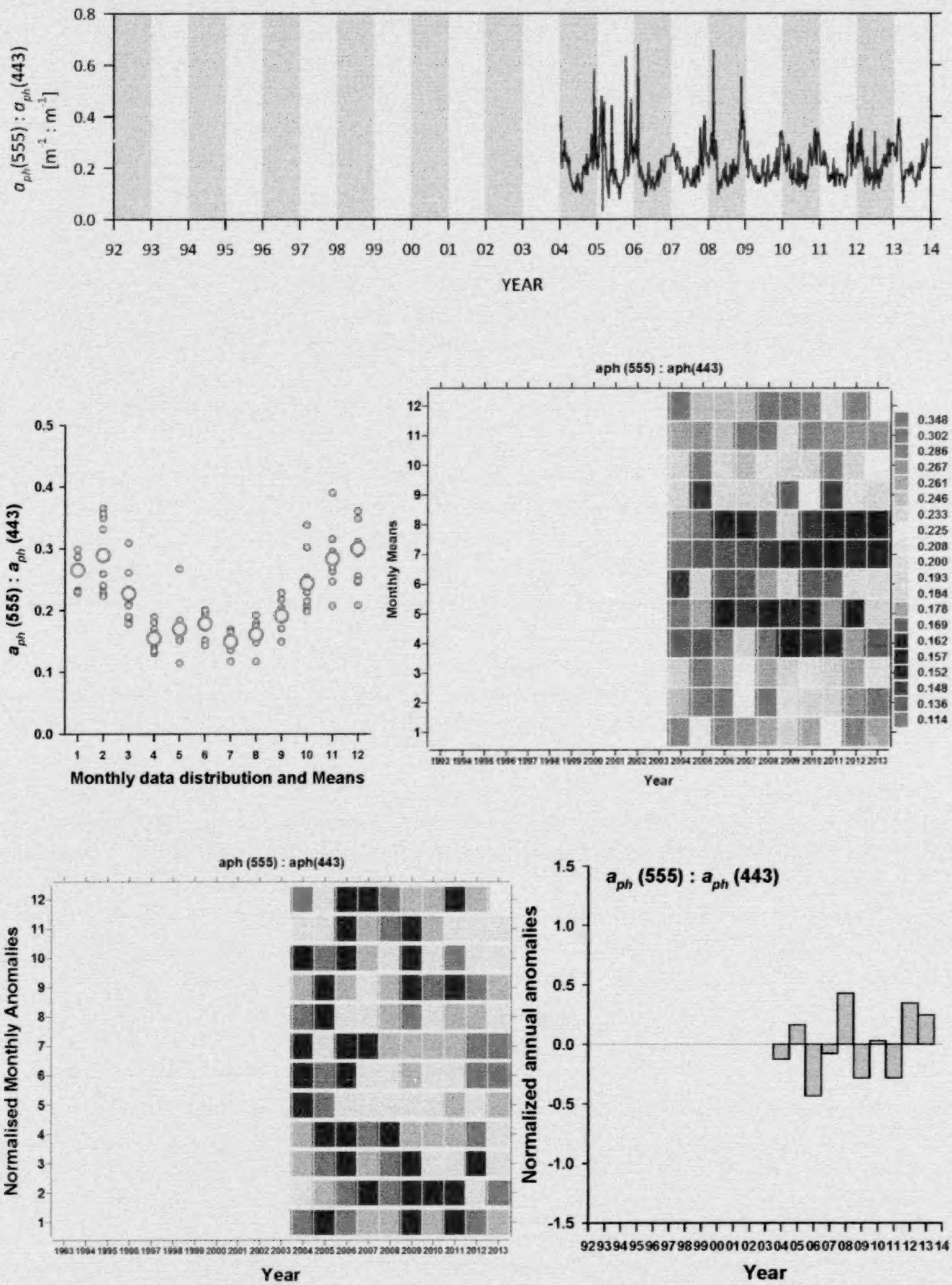


aph (676)
Normalised Monthly Anomalies
Year



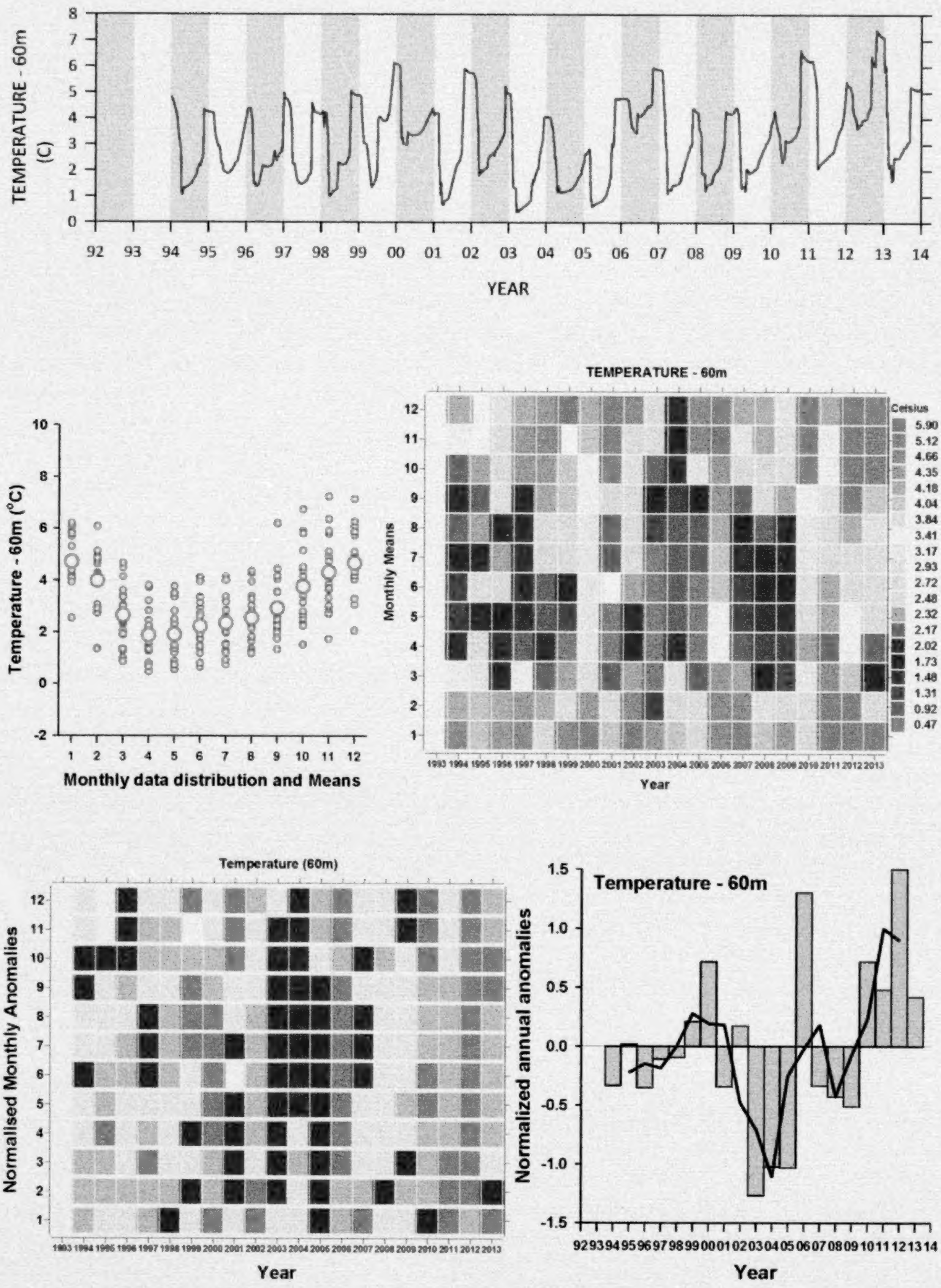
a_{ph} (676)
Normalized annual anomalies
Year

Figure 44



$a_{ph}(555) : a_{ph}(443)$ $[m^{-1} : m^{-1}]$
0.8
0.6
0.4
0.2
0.0
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
a_{ph} (555) : a_{ph} (443)
0.5
0.4
0.3
0.2
0.1
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Monthly data distribution and Means
aph (555) : aph(443)
Monthly Means
12 11 10 9 8 7 6 5 4 3 2 1
0.348 0.302 0.286 0.267 0.261 0.246 0.233 0.225 0.208 0.200 0.193 0.184 0.178 0.169 0.162 0.157 0.152 0.148 0.136 0.114
Year
aph (555) : aph(443)
Normalised Monthly Anomalies
12 11 10 9 8 7 6 5 4 3 2 1
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year
a_{ph} (555) : a_{ph} (443)
Normalized annual anomalies
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 45



TEMPERATURE - 60m (C)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Temperature - 60m (°C)
Monthly data distribution and Means
TEMPERATURE - 60m
Monthly Means
Celsius
5.90
5.12
4.66
4.35
4.18
4.04
3.84
3.41
3.17
2.93
2.72
2.48
2.32
2.17
2.02
1.73
1.48
1.31
0.92
0.47
Year
Temperature (60m)
Normalised Monthly Anomalies
Year
Temperature - 60m
Normalized annual anomalies
Year

Figure 46

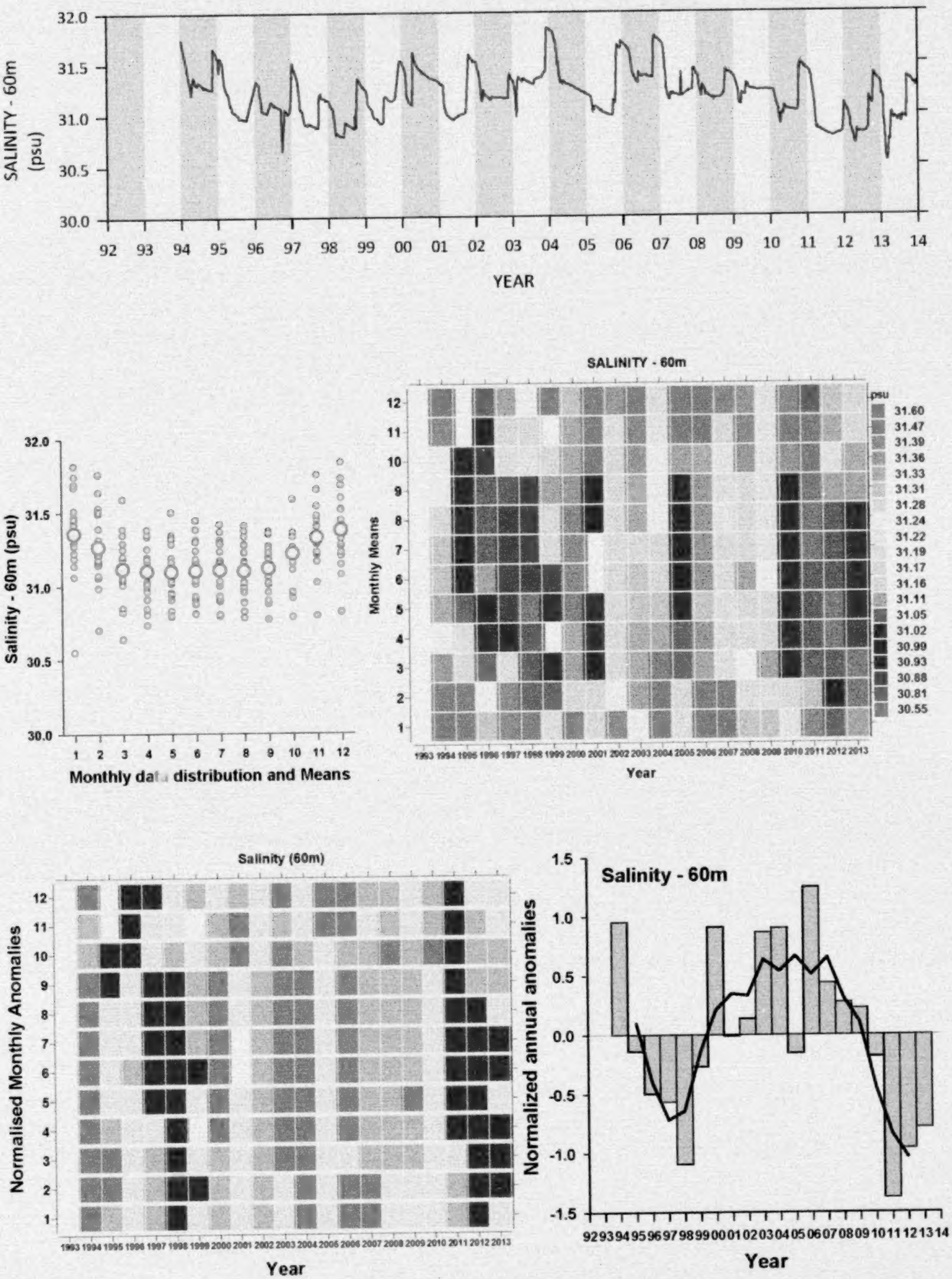
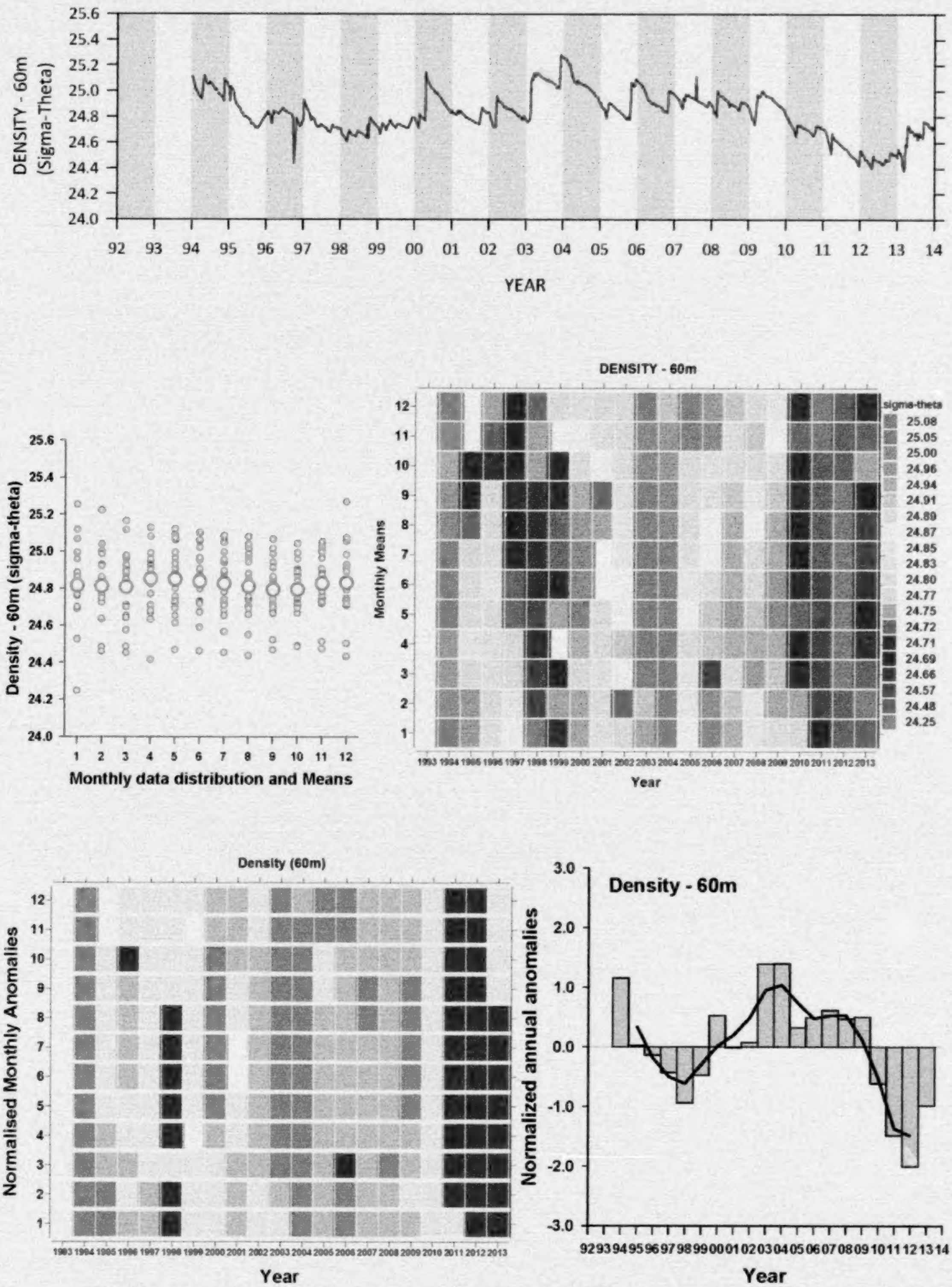

SALINITY - 60m (psu)
32.0
31.5
31.0
30.5
30.0
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
Salinity - 60m (psu)
Monthly data distribution and Means
SALINITY - 60m
Monthly Means
psu
31.60
31.47
31.39
31.36
31.33
31.31
31.28
31.24
31.22
31.19
31.17
31.16
31.11
31.05
31.02
30.99
30.93
30.88
30.81
30.55
Year
Salinity (60m)
Normalised Monthly Anomalies
Year
Salinity - 60m
Normalized annual anomalies
Year

Figure 47



DENSITY - 60m
(Sigma-Theta)
25.6
25.4
25.2
25.0
24.8
24.6
24.4
24.2
24.0
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
YEAR
Density - 60m (sigma-theta)
1 2 3 4 5 6 7 8 9 10 11 12
Monthly data distribution and Means
DENSITY - 60m
Monthly Means
sigma-theta
25.08
25.05
25.00
24.96
24.94
24.91
24.89
24.87
24.85
24.83
24.80
24.77
24.75
24.72
24.71
24.69
24.66
24.57
24.48
24.25
Year
Density (60m)
Normalised Monthly Anomalies
Year
Density - 60m
Normalized annual anomalies
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 48

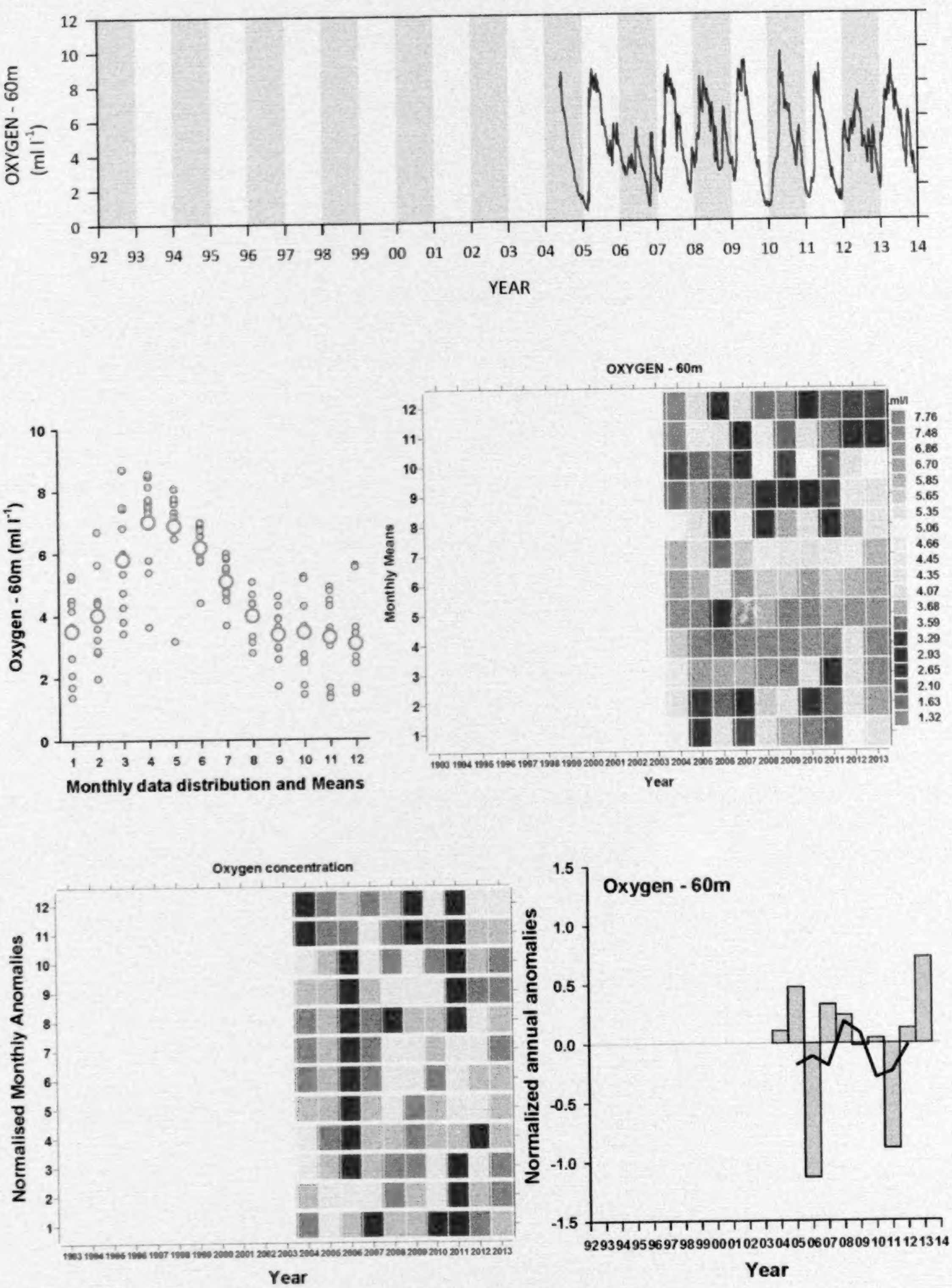
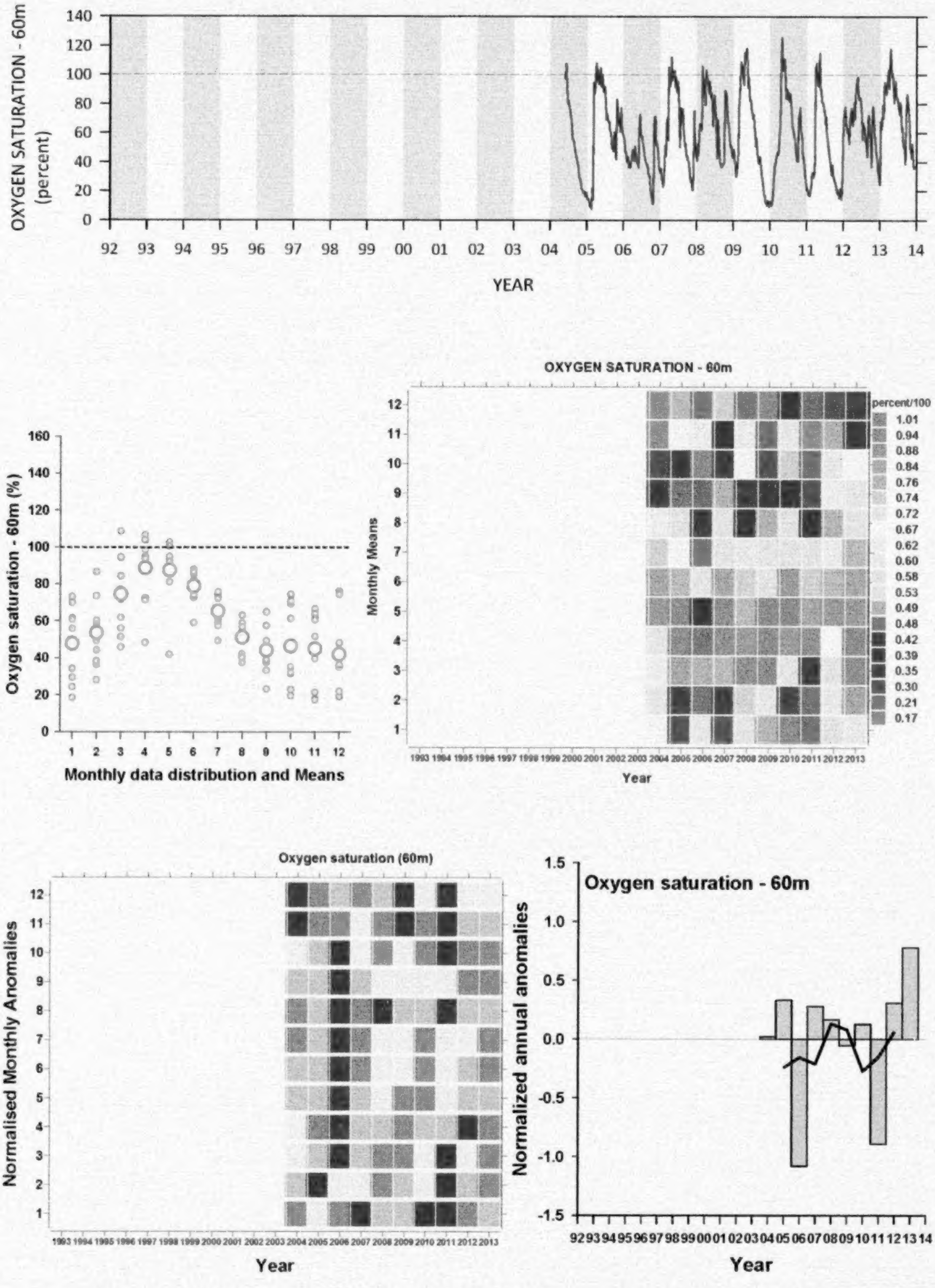

OXYGEN - 60m
(ml l⁻¹)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Oxygen - 60m (ml l⁻¹)
Monthly data distribution and Means
OXYGEN - 60m
Monthly Means
ml/l
7.76
7.48
6.86
6.70
5.85
5.65
5.35
5.06
4.66
4.45
4.35
4.07
3.68
3.59
3.29
2.93
2.65
2.10
1.63
1.32
Year
Oxygen concentration
Normalised Monthly Anomalies
Year
Oxygen - 60m
Normalized annual anomalies
Year

Figure 49



OXYGEN SATURATION - 60m (percent)
YEAR
Oxygen saturation - 60m (%)
Monthly data distribution and Means
OXYGEN SATURATION - 60m
Monthly Means
percent/100
1.01
0.94
0.88
0.84
0.76
0.74
0.72
0.67
0.62
0.60
0.58
0.53
0.49
0.48
0.42
0.39
0.35
0.30
0.21
0.17
Year
Oxygen saturation (60m)
Normalised Monthly Anomalies
Year
Oxygen saturation - 60m
Normalized annual anomalies
Year

Figure 50

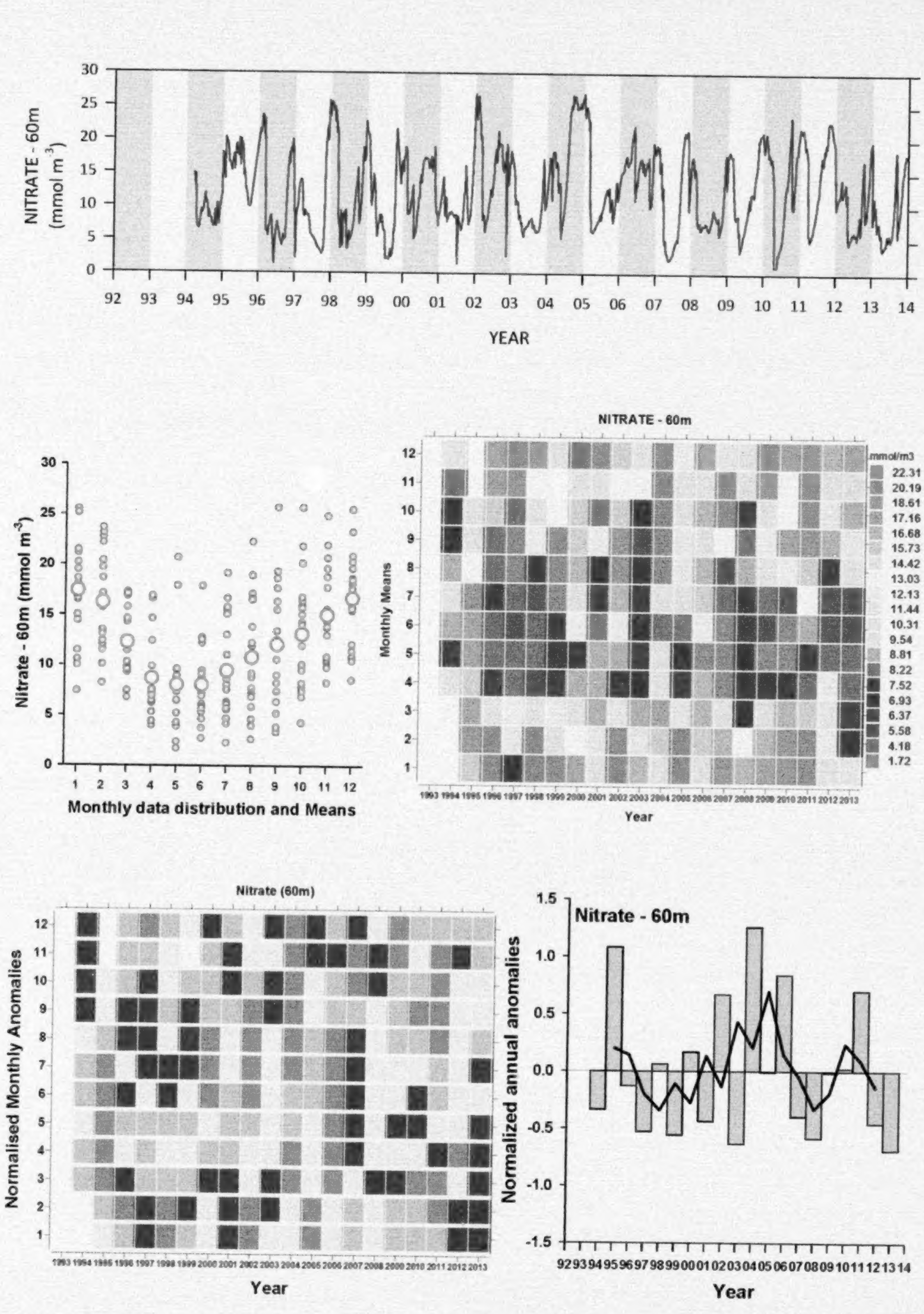

NITRATE - 60m (mmol m^{-3})
YEAR
Nitrate - 60m (mmol m^{-3})
Monthly data distribution and Means
NITRATE - 60m
Monthly Means
mmol/m3
22.31
20.19
18.61
17.16
16.68
15.73
14.42
13.03
12.13
11.44
10.31
9.54
8.81
8.22
7.52
6.93
6.37
5.58
4.18
1.72
Year
Nitrate (60m)
Normalised Monthly Anomalies
Year
Nitrate - 60m
Normalized annual anomalies
Year

Figure 51

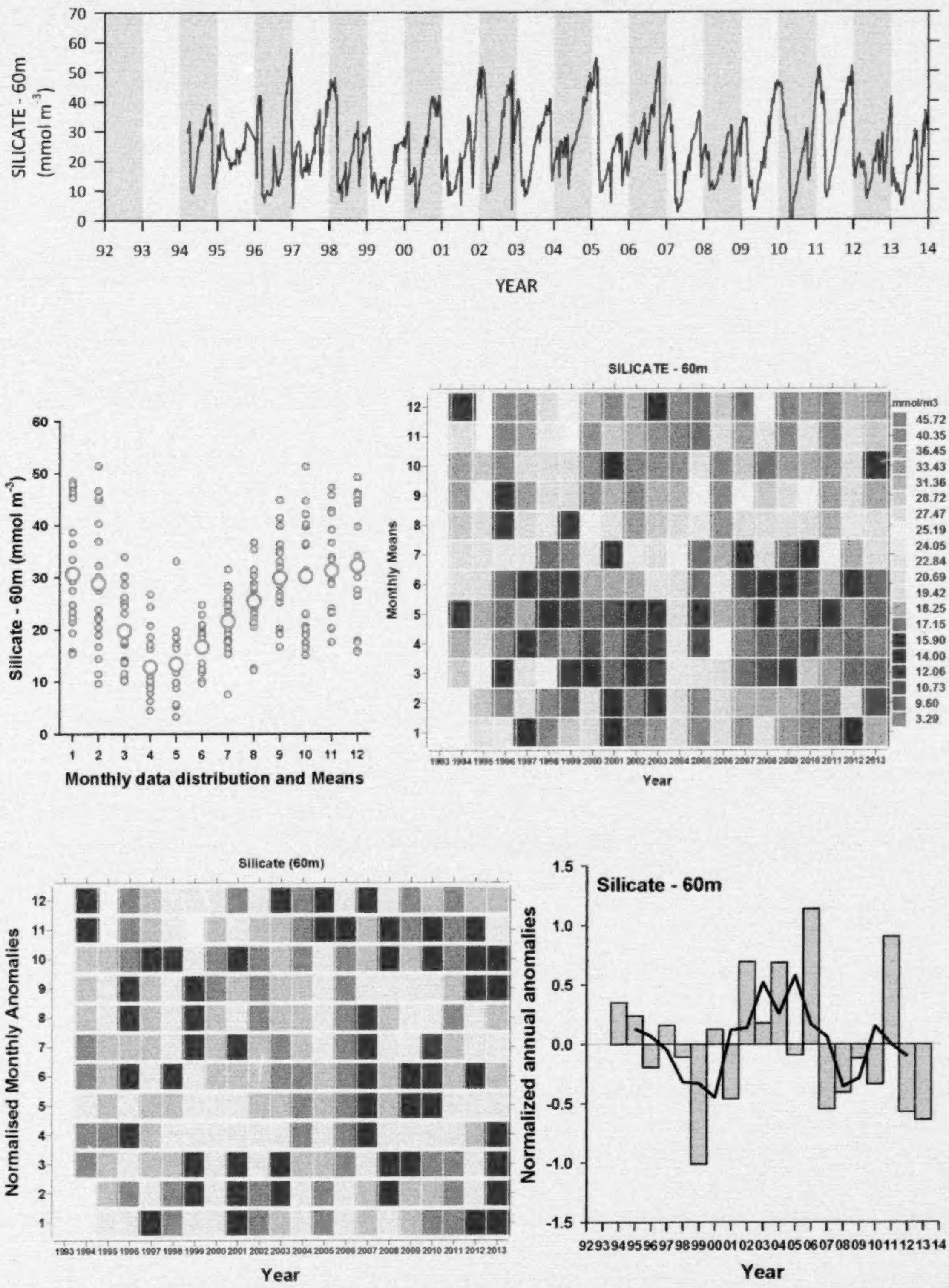

SILICATE - 60m (mmol m^{-3})
YEAR
Silicate - 60m (mmol m^{-3})
Monthly data distribution and Means
SILICATE - 60m
Monthly Means
Year
mmol/m3
45.72
40.35
36.45
33.43
31.36
28.72
27.47
25.19
24.05
22.84
20.69
19.42
18.25
17.15
15.90
14.00
12.06
10.73
9.60
3.29
Silicate (60m)
Normalised Monthly Anomalies
Year
Silicate - 60m
Normalized annual anomalies
Year

Figure 52

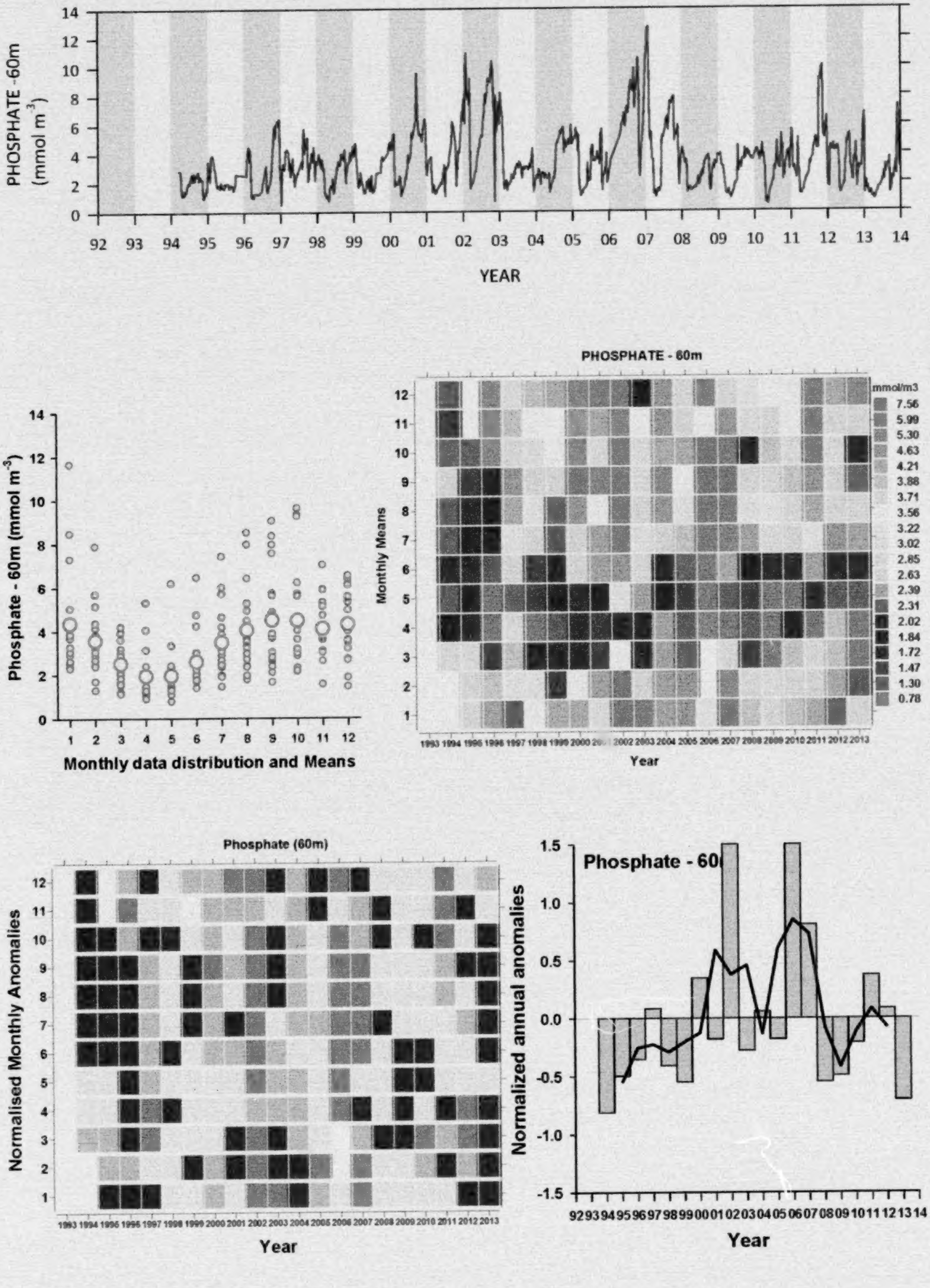

PHOSPHATE -60m (mmol m^{-3})
YEAR
Phosphate - 60m (mmol m^{-3})
Monthly data distribution and Means
PHOSPHATE - 60m
Monthly Means
mmol/m3
7.56
5.99
5.30
4.63
4.21
3.88
3.71
3.56
3.22
3.02
2.85
2.63
2.39
2.31
2.02
1.84
1.72
1.47
1.30
0.78
Year
Phosphate (60m)
Normalised Monthly Anomalies
Year
Phosphate - 60
Normalized annual anomalies
Year

Figure 53

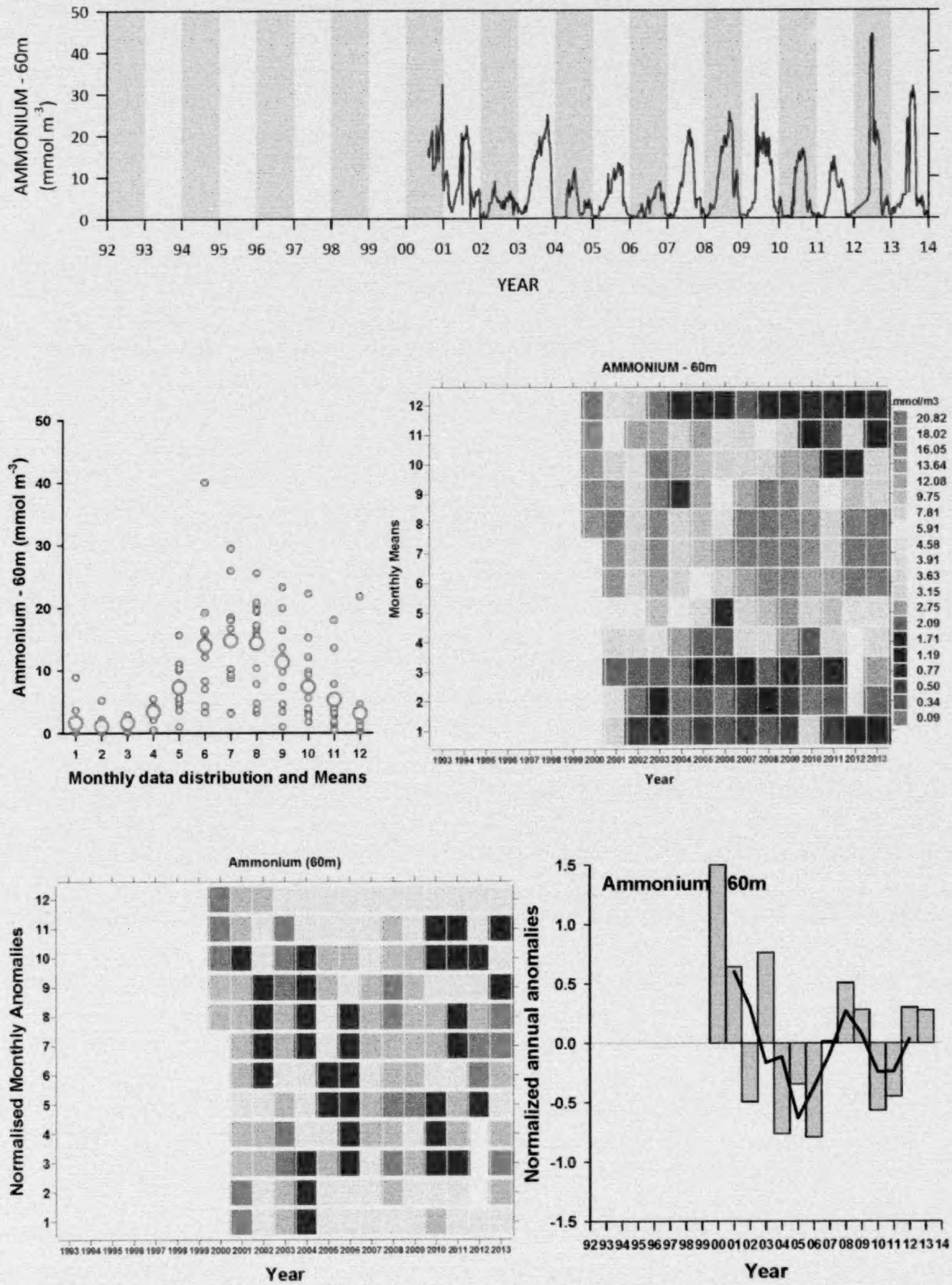
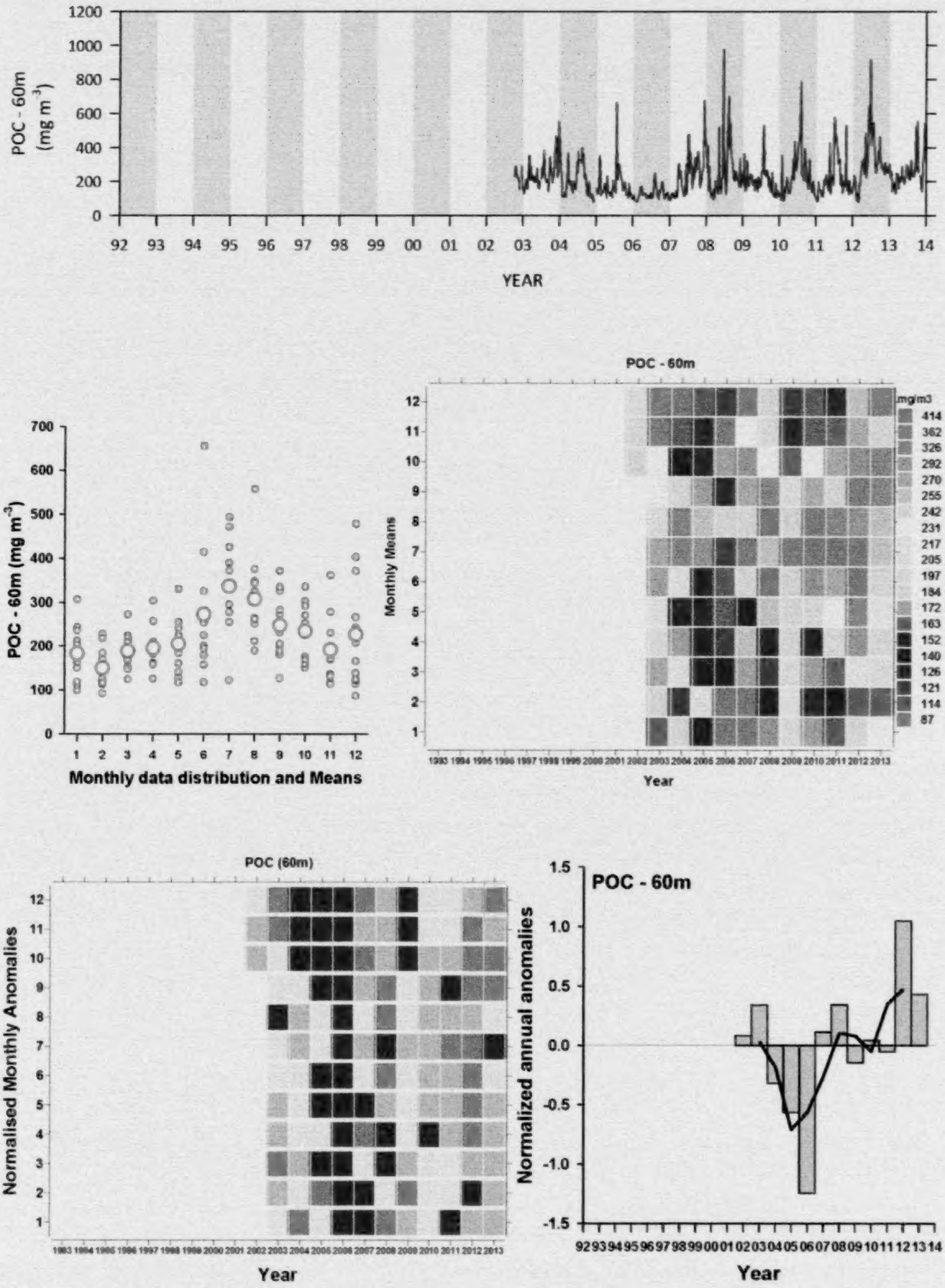

AMMONIUM - 60m
(mmol m-3)
YEAR
Ammonium - 60m (mmol m-3)
Monthly data distribution and Means
AMMONIUM - 60m
Monthly Means
mmol/m3
20.82
18.02
16.05
13.64
12.08
9.75
7.81
5.91
4.58
3.91
3.63
3.15
2.75
2.09
1.71
1.19
0.77
0.50
0.34
0.09
Year
Ammonium (60m)
Normalised Monthly Anomalies
Year
Ammonium 60m
Normalized annual anomalies
Year

Figure 54



POC - 60m
(mg m^{-3})
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
POC - 60m (mg m^{-3})
Monthly data distribution and Means
POC - 60m
Monthly Means
mg/m3
414
362
326
292
270
255
242
231
217
205
197
184
172
163
152
140
126
121
114
87
Year
POC (60m)
Normalised Monthly Anomalies
Year
POC - 60m
Normalized annual anomalies
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Year

Figure 55

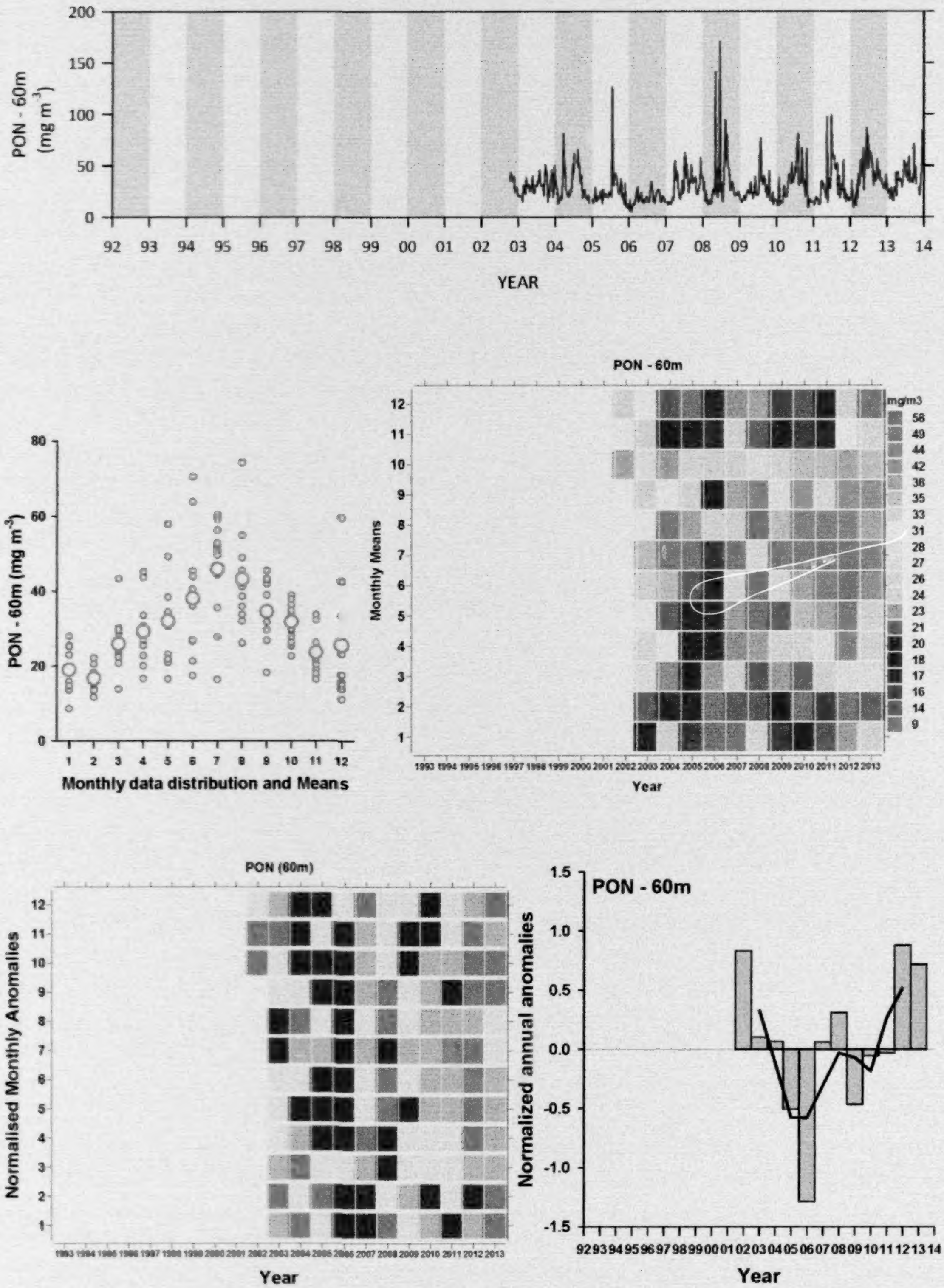

PON - 60m
(mg m^{-3})
YEAR
PON - 60m (mg m^{-3})
Monthly data distribution and Means
PON - 60m
Monthly Means
Year
mg/m3
PON (60m)
Normalised Monthly Anomalies
Year
PON - 60m
Normalized annual anomalies
Year

Figure 56

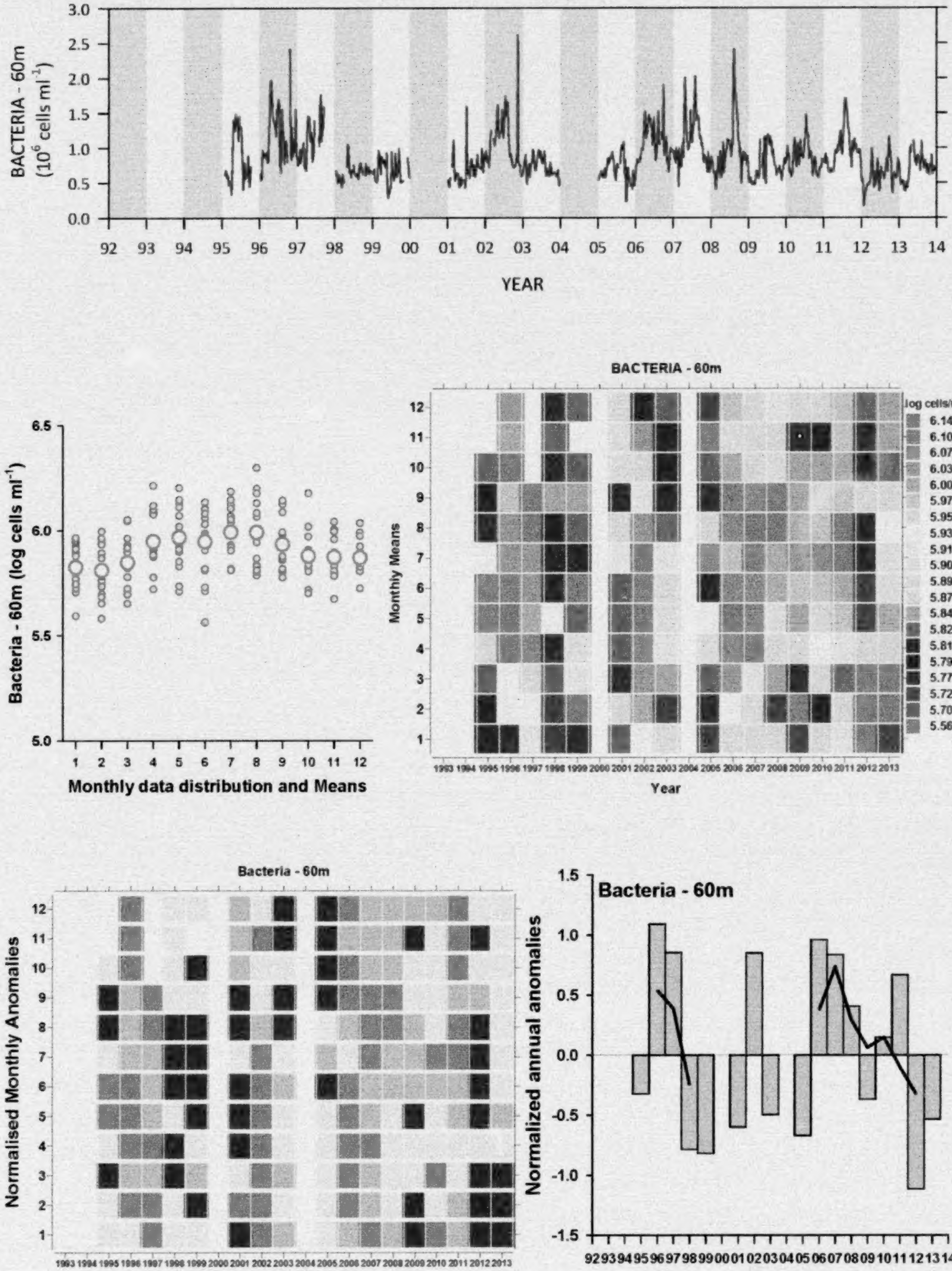

BACTERIA - 60m
(10^6 cells ml^{-1})
YEAR
BACTERIA - 60m
Bacteria - 60m (log cells ml^{-1})
Monthly data distribution and Means
Monthly Means
log cells/ml
Year
Bacteria - 60m
Normalised Monthly Anomalies
Year
Bacteria - 60m
Normalized annual anomalies
Year

Figure 57

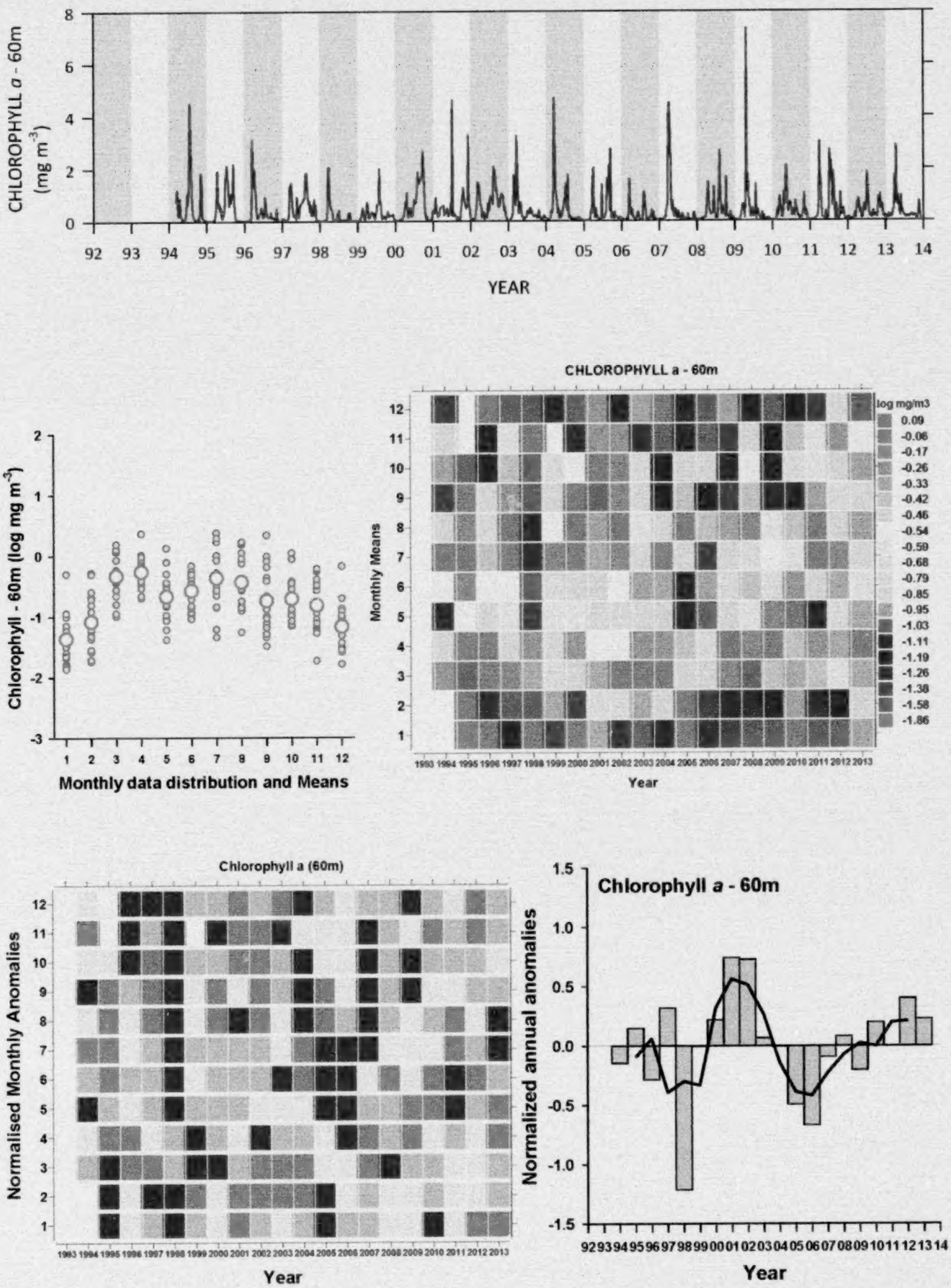

CHLOROPHYLL a - 60m (mg m-3)
YEAR
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
Chlorophyll - 60m (log mg m-3)
Monthly data distribution and Means
CHLOROPHYLL a - 60m
Monthly Means
log mg/m3
0.09
-0.06
-0.17
-0.26
-0.33
-0.42
-0.46
-0.54
-0.59
-0.68
-0.79
-0.85
-0.95
-1.03
-1.11
-1.19
-1.26
-1.38
-1.58
-1.86
Year
Chlorophyll a (60m)
Normalised Monthly Anomalies
Year
Chlorophyll a - 60m
Normalized annual anomalies
Year

Figure 58

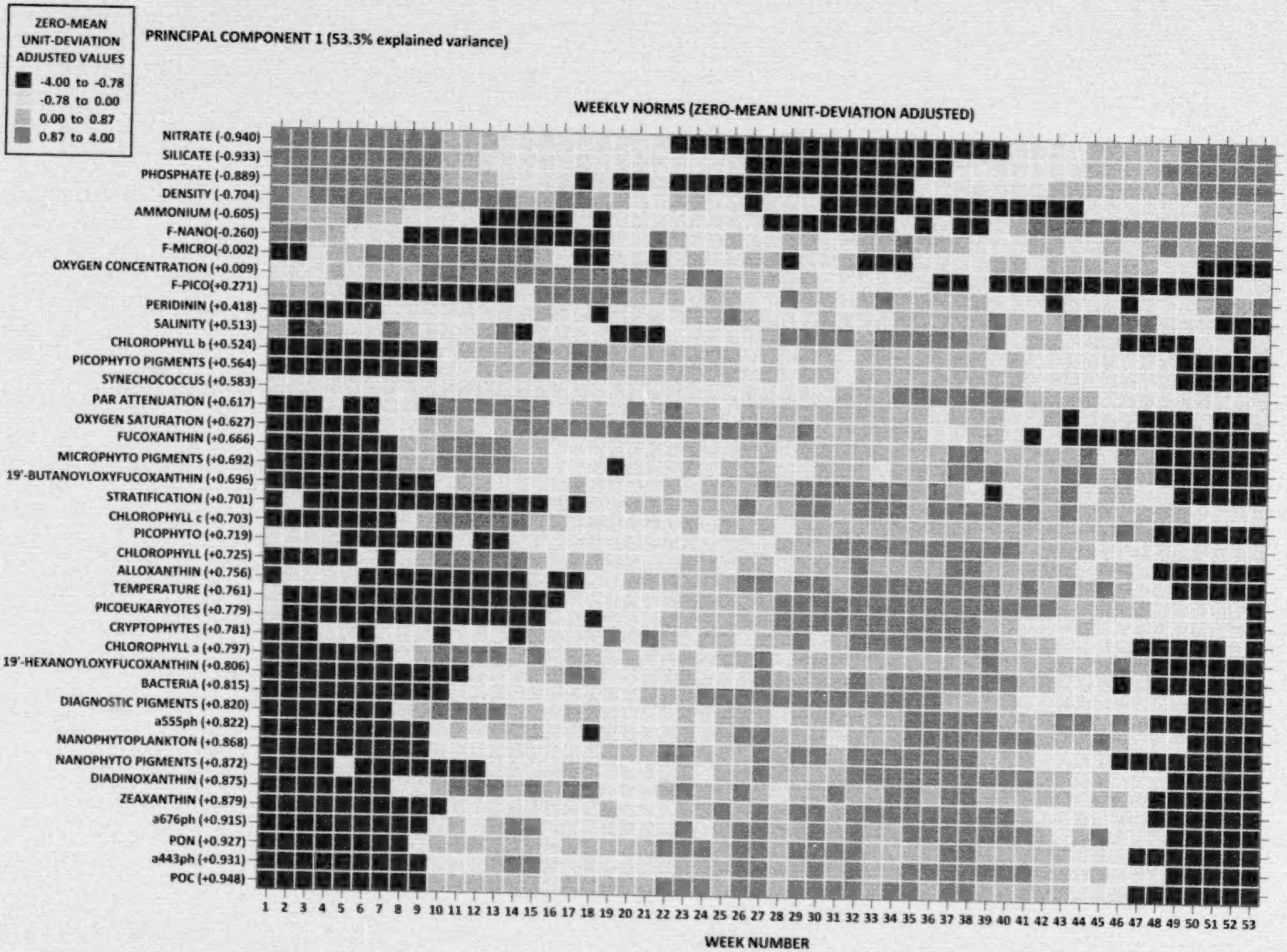

ZERO-MEAN UNIT-DEVIATION ADJUSTED VALUES
-4.00 to -0.78
-0.78 to 0.00
0.00 to 0.87
0.87 to 4.00
PRINCIPAL COMPONENT 1 (53.3% explained variance)
WEEKLY NORMS (ZERO-MEAN UNIT-DEVIATION ADJUSTED)
NITRATE (-0.940)
SILICATE (-0.933)
PHOSPHATE (-0.889)
DENSITY (-0.704)
AMMONIUM (-0.605)
F-NANO(-0.260)
F-MICRO(-0.002)
OXYGEN CONCENTRATION (+0.009)
F-PICO(+0.271)
PERIDININ (+0.418)
SALINITY (+0.513)
CHLOROPHYLL b (+0.524)
PICOPHYTO PIGMENTS (+0.564)
SYNECHOCOCCUS (+0.583)
PAR ATTENUATION (+0.617)
OXYGEN SATURATION (+0.627)
FUCOXANTHIN (+0.666)
MICROPHYTO PIGMENTS (+0.692)
19'-BUTANOYLOXYFUCOXANTHIN (+0.696)
STRATIFICATION (+0.701)
CHLOROPHYLL c (+0.703)
PICOPHYTO (+0.719)
CHLOROPHYLL (+0.725)
ALLOXANTHIN (+0.756)
TEMPERATURE (+0.761)
PICOEUKARYOTES (+0.779)
CRYPTOPHYTES (+0.781)
CHLOROPHYLL a (+0.797)
19'-HEXANOYLOXYFUCOXANTHIN (+0.806)
BACTERIA (+0.815)
DIAGNOSTIC PIGMENTS (+0.820)
a555ph (+0.822)
NANOPHYTOPLANKTON (+0.868)
NANOPHYTO PIGMENTS (+0.872)
DIADINOXANTHIN (+0.875)
ZEAXANTHIN (+0.879)
a676ph (+0.915)
PON (+0.927)
a443ph (+0.931)
POC (+0.948)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53
WEEK NUMBER

Figure 59

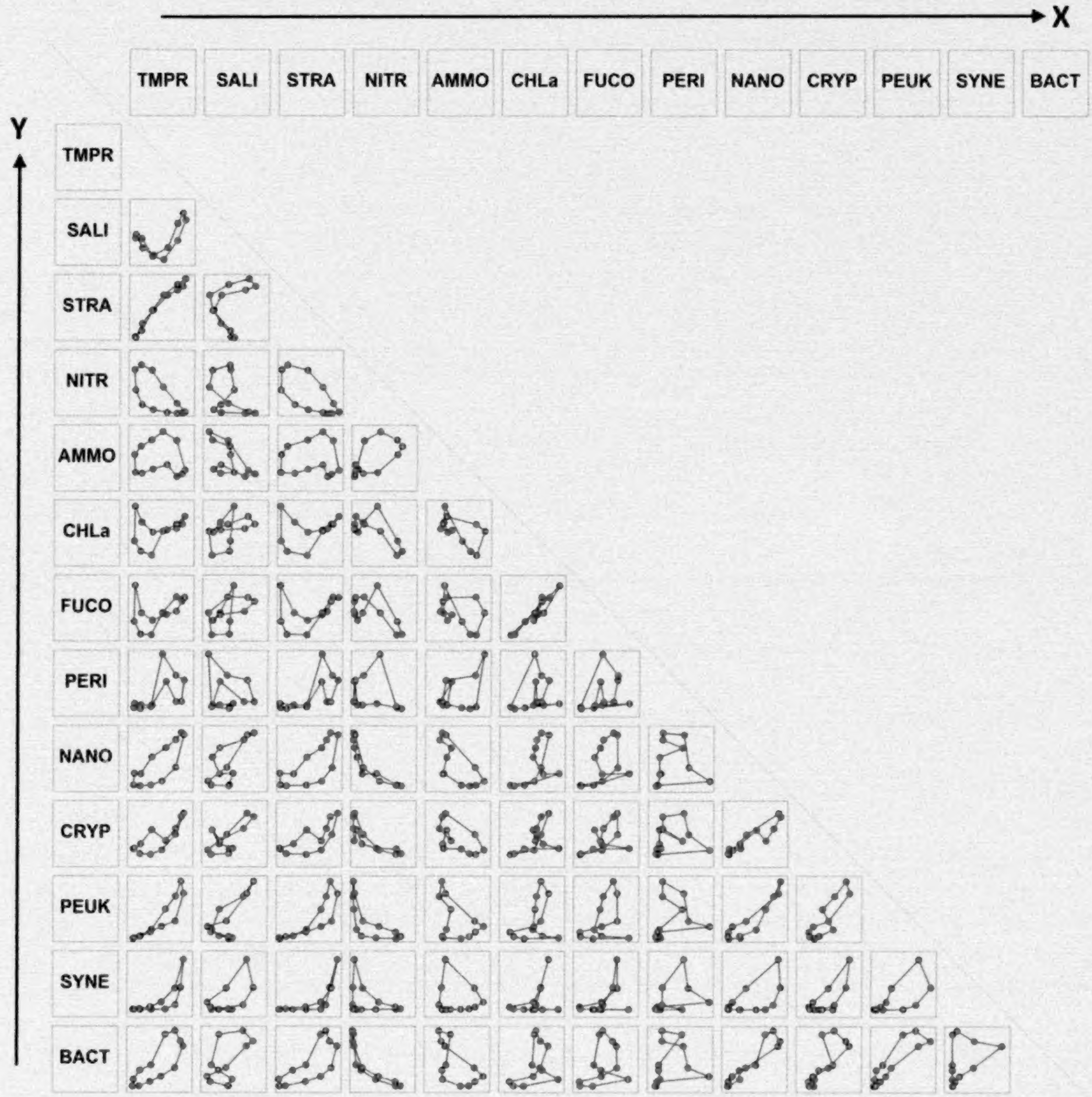

X
TMPR
SALI
STRA
NITR
AMMO
CHLa
FUCO
PERI
NANO
CRYP
PEUK
SYNE
BACT
Y
TMPR
SALI
STRA
NITR
AMMO
CHLa
FUCO
PERI
NANO
CRYP
PEUK
SYNE
BACT

Figure 60

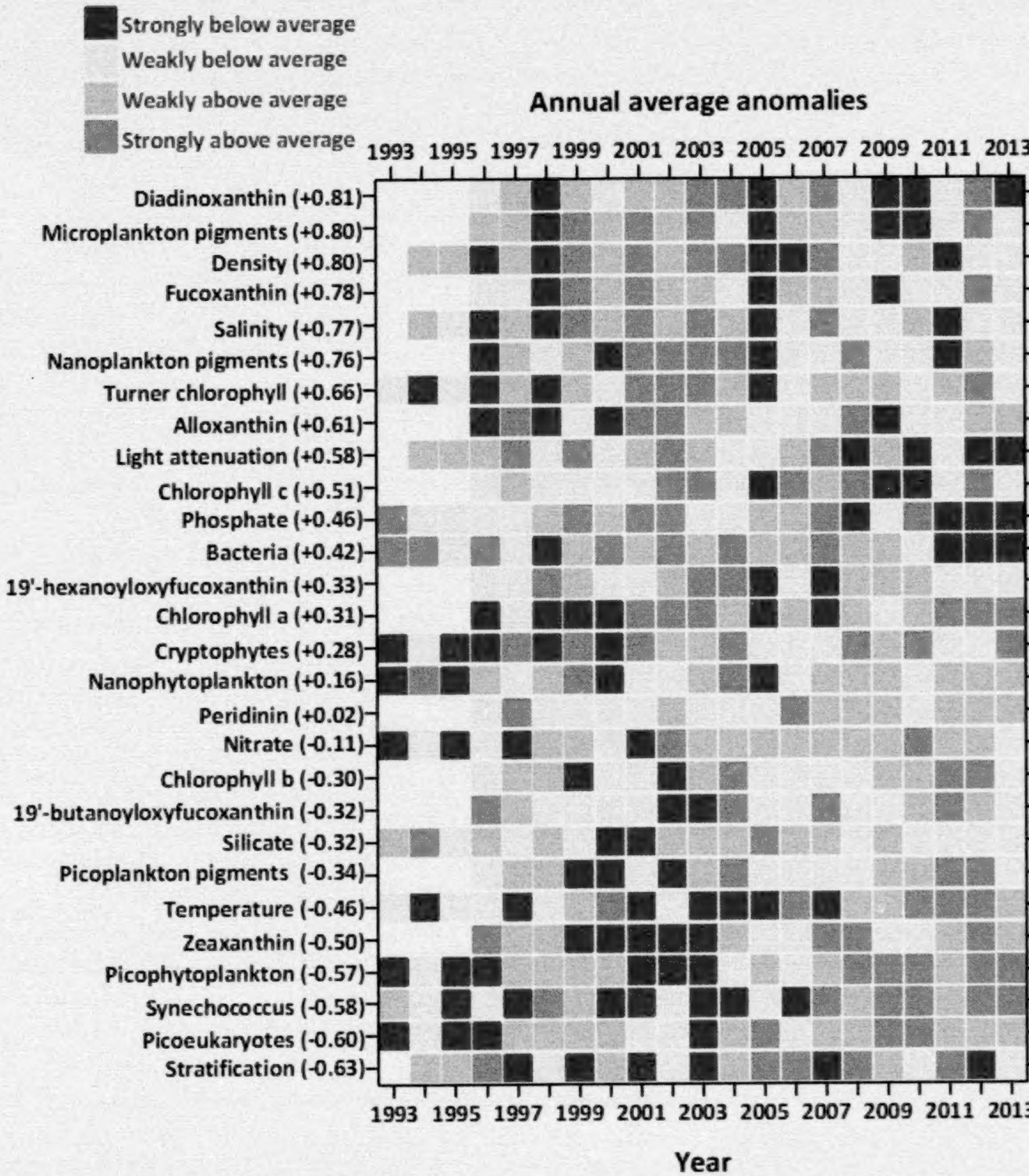

Strongly below average
Weakly below average
Weakly above average
Strongly above average
Annual average anomalies
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Diadinoxanthin (+0.81)
Microplankton pigments (+0.80)
Density (+0.80)
Fucoxanthin (+0.78)
Salinity (+0.77)
Nanoplankton pigments (+0.76)
Turner chlorophyll (+0.66)
Alloxanthin (+0.61)
Light attenuation (+0.58)
Chlorophyll c (+0.51)
Phosphate (+0.46)
Bacteria (+0.42)
19'-hexanoyloxyfucoxanthin (+0.33)
Chlorophyll a (+0.31)
Cryptophytes (+0.28)
Nanophytoplankton (+0.16)
Peridinin (+0.02)
Nitrate (-0.11)
Chlorophyll b (-0.30)
19'-butanoyloxyfucoxanthin (-0.32)
Silicate (-0.32)
Picoplankton pigments (-0.34)
Temperature (-0.46)
Zeaxanthin (-0.50)
Picophytoplankton (-0.57)
Synechococcus (-0.58)
Picoeukaryotes (-0.60)
Stratification (-0.63)
Year

Figure 61

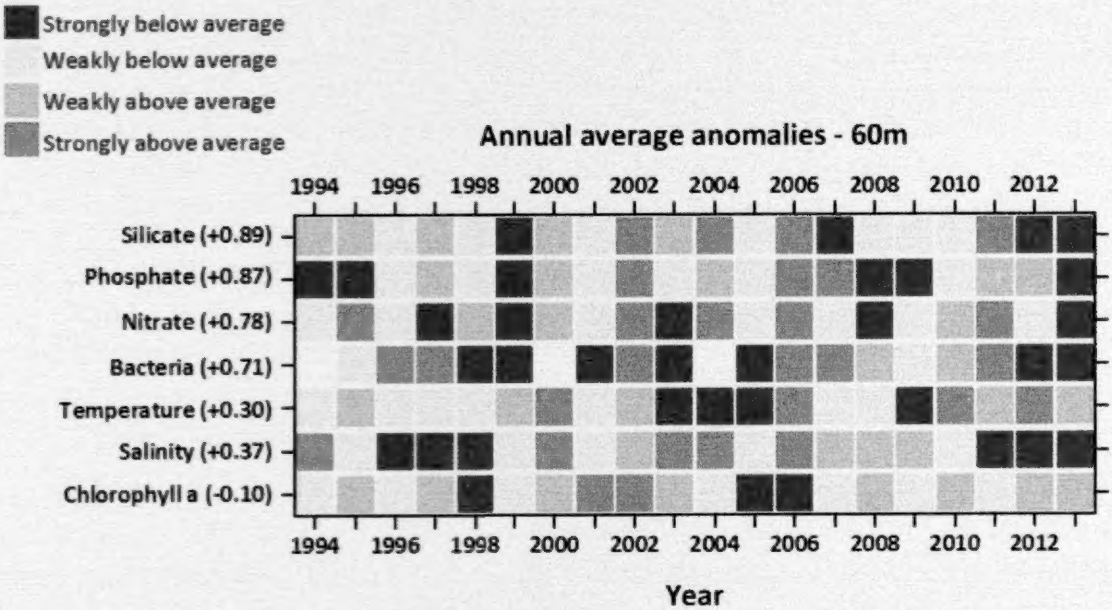

Strongly below average
Weakly below average
Weakly above average
Strongly above average
Annual average anomalies - 60m
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Silicate (+0.89)
Phosphate (+0.87)
Nitrate (+0.78)
Bacteria (+0.71)
Temperature (+0.30)
Salinity (+0.37)
Chlorophyll a (-0.10)
Year

Figure 62

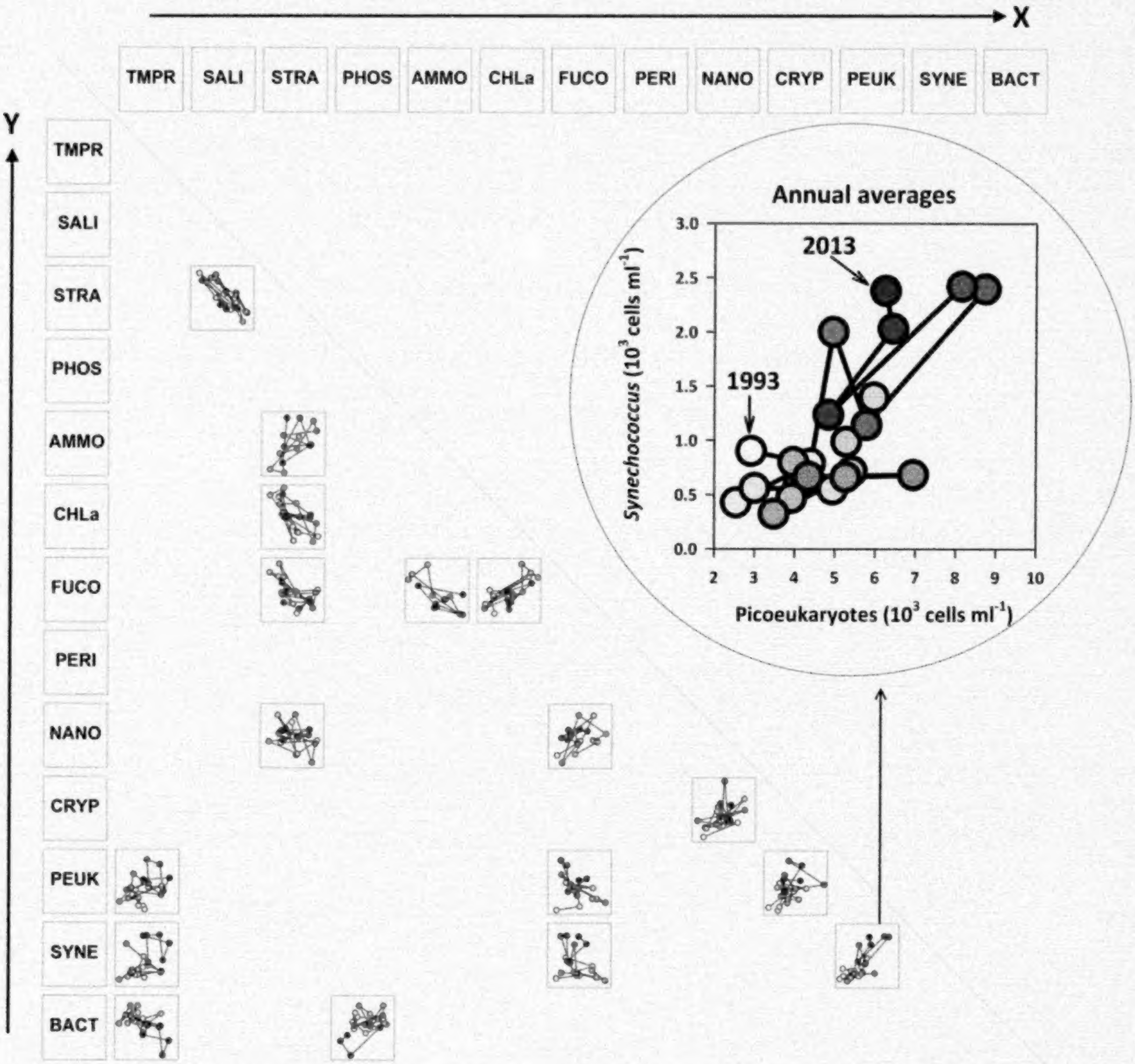

X
Y
TMPR
SALI
STRA
PHOS
AMMO
CHLa
FUCO
PERI
NANO
CRYP
PEUK
SYNE
BACT
Annual averages
2013
1993
Synechococcus (10³ cells ml⁻¹)
Picoeukaryotes (10³ cells ml⁻¹)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2
3
4
5
6
7
8
9
10

Figure 63

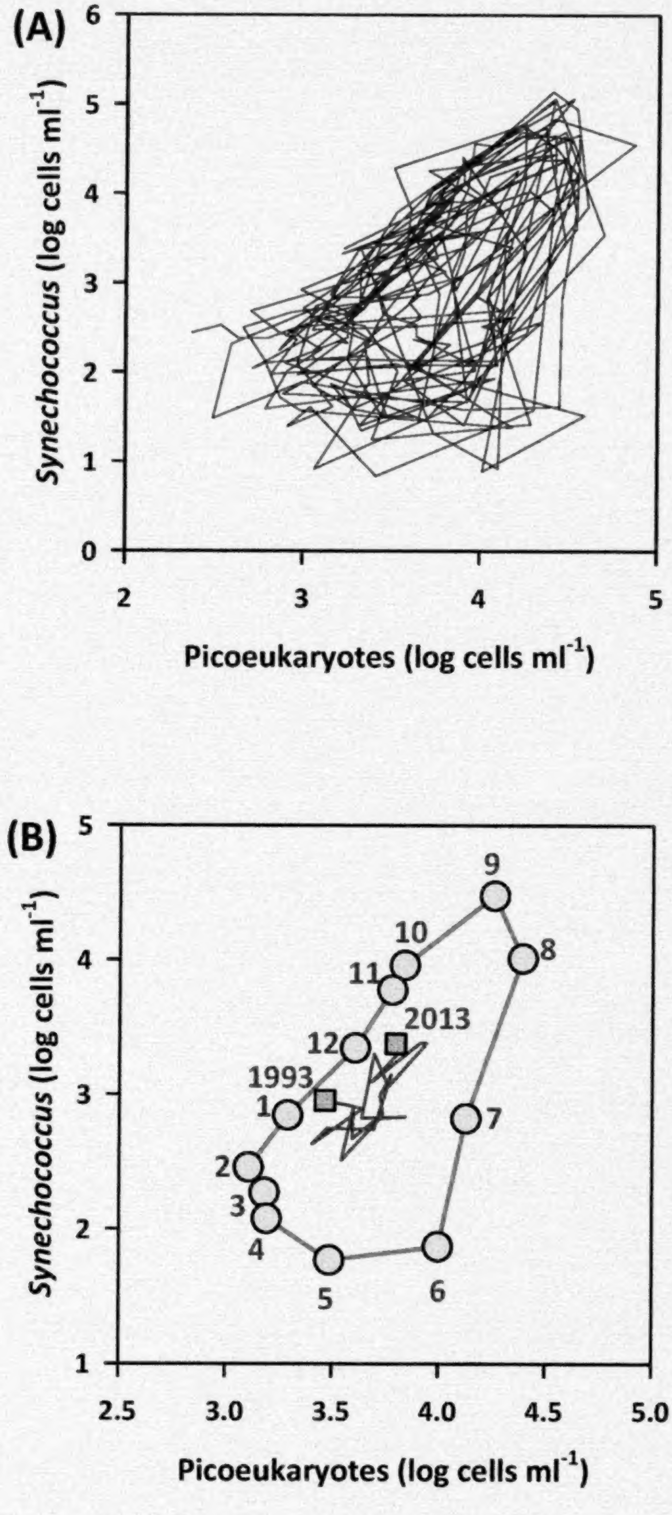
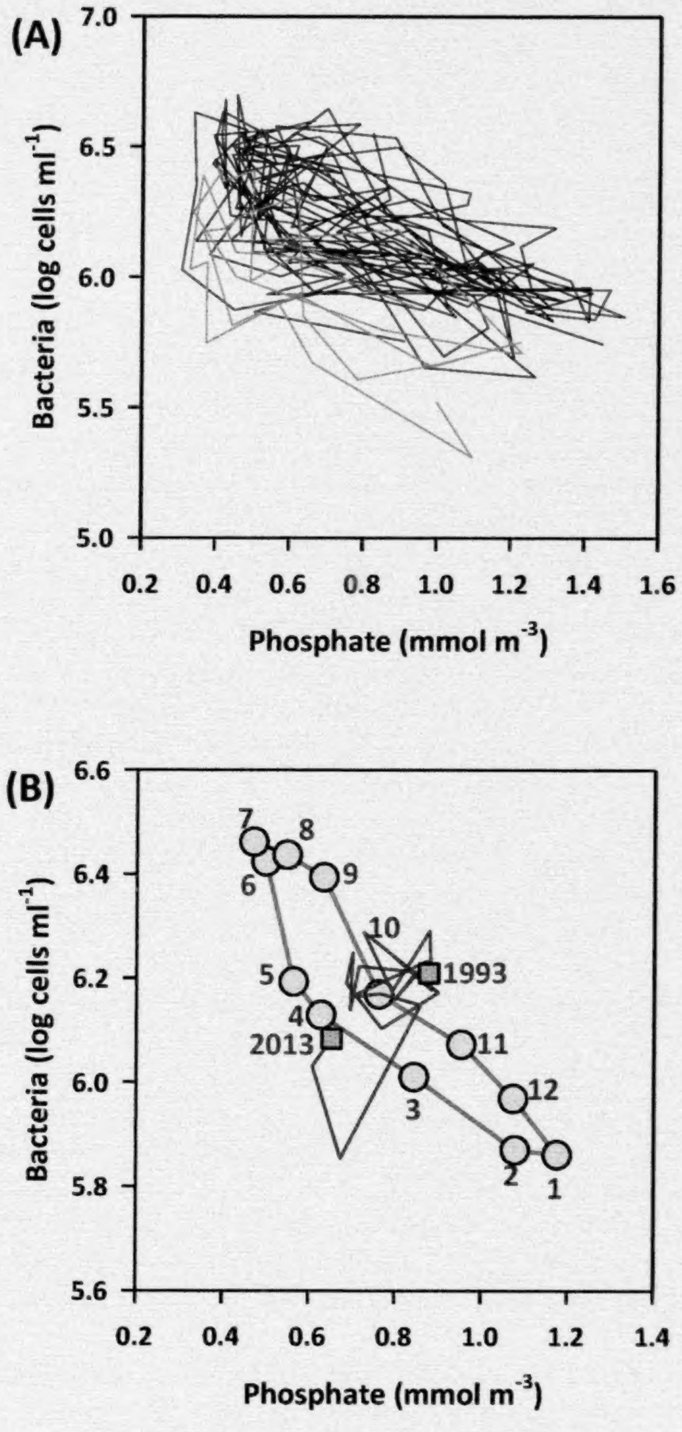

(A)
Synechococcus (log cells ml^{-1})
Picoeukaryotes (log cells ml^{-1})
0
1
2
3
4
5
6
2
3
4
5
(B)
Synechococcus (log cells ml^{-1})
Picoeukaryotes (log cells ml^{-1})
1
2
3
4
5
2.5
3.0
3.5
4.0
4.5
5.0
1
2
3
4
5
6
7
8
9
10
11
12
1993
2013

Figure 64


(A)
Bacteria (log cells ml-1)
Phosphate (mmol m-3)
(B)
Bacteria (log cells ml-1)
Phosphate (mmol m-3)
1993
2013
1
2
3
4
5
6
7
8
9
10
11
12